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HAVO | VWO

your biology
TEXTBOOK

your biology

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**Your Biology
TEXTBOOK**



BIOLOGIE VOOR TWEETALIG ONDERWIJS
HAVO|VWO ONDERBOUW

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Introduction

This biology book is the first part of *Your Biology*. Browsing through the book will show you exactly how it is structured. The way we wrote this book will let you work with it on your own.

You can also ask your teacher for help if you need it.

There is a workbook that belongs with this book, as well as an answer key and the Your Biology website. The website contains a digital version of the workbook and/or textbook. There is also the possibility for practising with digital material (including the diagnostic tests).

WORKING WITH YOUR BIOLOGY

The topics in this book are called units. Each unit starts off with an introduction.

This gives a brief description of what you can expect in the unit.

Each unit is made up of the following sections:

- Basics
- Extra
- Summary
- Diagnostic test
- Extension

We will now describe how to work with each of these sections.

BASICS

The Basics contain texts and figures that you are going to read. You will come across references to the exercises that are in the workbook, for example:

WB EXERCISES 1 AND 2, PAGE 4

You should do the exercises in your workbook.

There is sometimes an optional exercise at the end of the Basics. Your teacher will tell you whether you have to do the optional exercise.

When you have finished the exercises, you will find a reference back to the textbook, for example:

TB BASICS 2, PAGE 10

Sometimes you will have to use the Internet for an exercise.

There are also some exercises that you need a worksheet for. The worksheets are in the workbook. It is useful if you have a pair of scissors and a glue stick. As well as the pens you normally write with, you will need a drawing pencil (HB) and coloured pencils.

You can use the answer key to check the exercises yourself.

EXTRA

At the end of the Basics, you will find the Extra section. Once you have finished the Basics, your teacher will tell you whether you have to do the Extra.

The completed exercises from the Extra section can be checked with the answer key.

SUMMARY

The summary gives a brief description of what you have learned in the basics and (if you did it) the Extra section. This is what you will have to know and be able to do for a test.

DIAGNOSTIC TEST

The diagnostic test lets you see whether you know and can do everything that is in the summary. You can check the diagnostic test using the answer key.

You can also do the diagnostic test via the Your Biology website. You can then see straight away whether your answers are correct.

EXTENSION

If you know and can do everything that is in the summary, you can start on the Extension. This is additional material, with different sections that you can choose between. You do not have to do all the sections; your teacher will tell you how many you have to choose.

The exercises in the Extension can also be checked using the answer key.

We hope that you will enjoy working with this book.

The authors

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1

What is biology?



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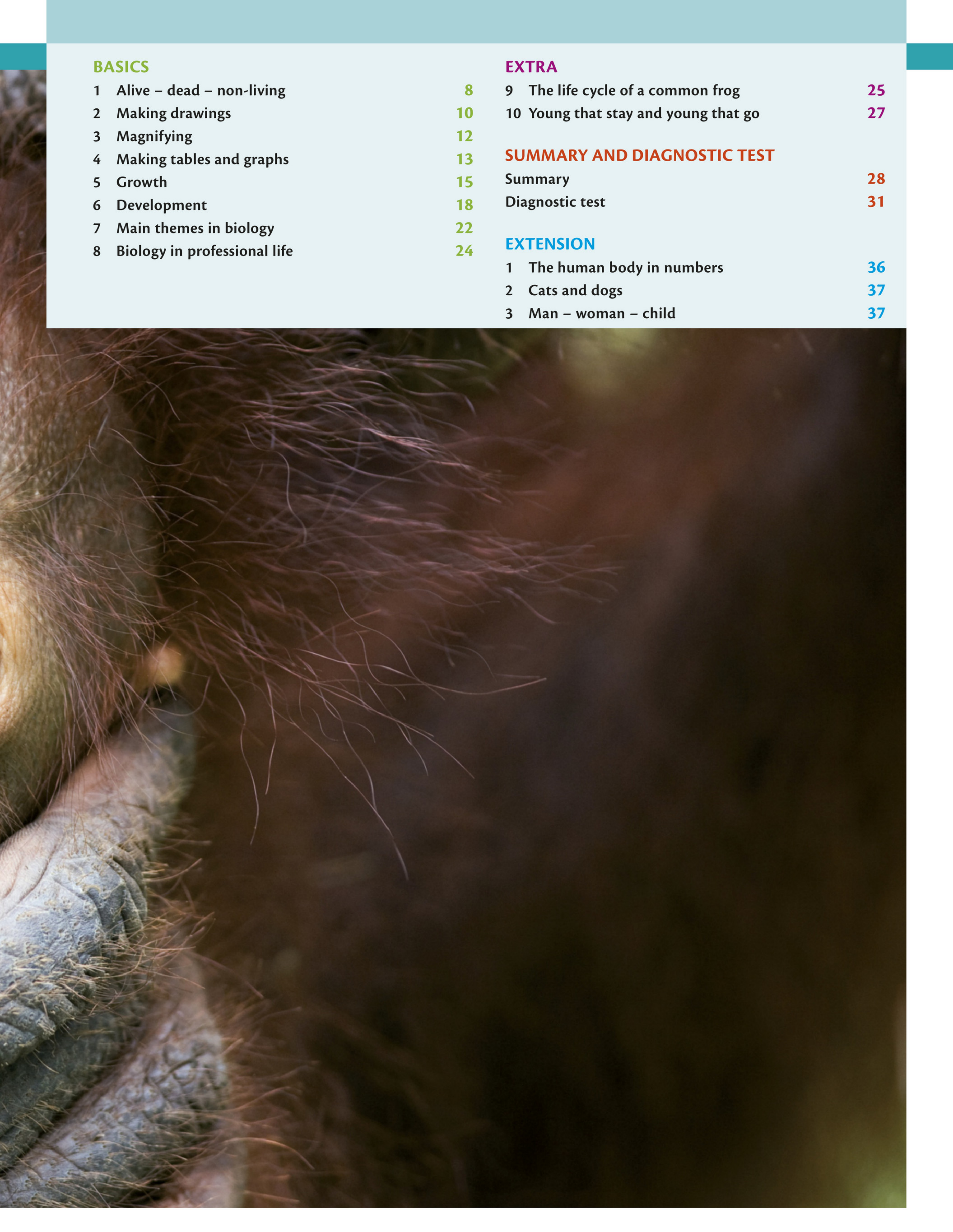
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This unit is called 'What is biology?' In this unit, you will get some idea of what biology is going to be teaching you about.

In biology, we study living things. Observation is an important part of this. If you observe things very closely, you can learn a great deal about living things.

To let other people see what you have observed, you must record your observations.

This is why biologists make lots of drawings. This unit will also teach you other ways of recording your observations.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Living – dead – non-living

The word 'biology' is derived from the Greek words **bios** (= life) and **logos** (= teaching or science). **Biology is the study of life.**

In biology, we study **living things**. A living thing is also called an **organism**. People, animals and plants are all organisms, for instance. In biology, people are seen as just another type of animal. Unit 4 Classification will also teach you that bacteria and fungi are also organisms.

The ways organisms behave or act are known as **life processes**. All organisms breathe, for example. When an organism stops carrying out life processes, we say that it is **dead**.

There are also natural objects that have never been alive. We refer to these as **non-living**. Rocks, air and water are all non-living, for example. The non-living aspects of nature have a huge influence on living nature (see figure 1).

WB EXERCISES 1 AND 2, PAGE 6

▼ **Fig. 1** Living – dead – non-living.



LIFE PROCESSES

Organisms behave in ways known as life processes. The fact that they exhibit these characteristics helps you separate them from non-living natural objects. Life processes are the **characteristics** of life.

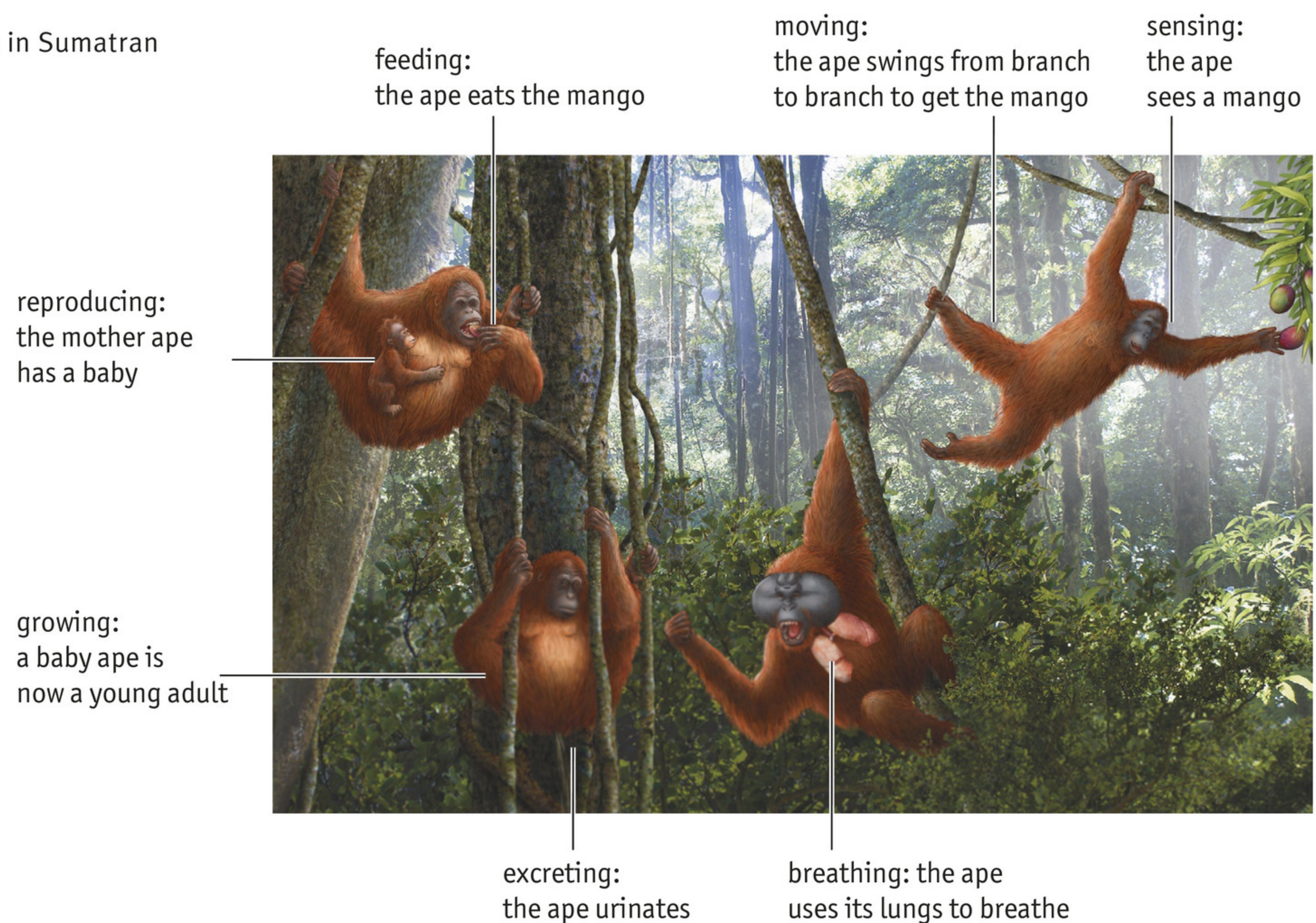
A number of these life processes involve taking in and getting rid of substances. Organisms take up a variety of substances from their surroundings, for instance when they **feed** and when they **breathe**.

Substances enter your body when you eat, drink or breathe. Your body uses these substance to help it stay alive. Your body also gets rid of substances into its surroundings, for instance when you urinate or when you breathe out. This release of substances to the surroundings is known as **excretion**.

Organisms respond to their surroundings. Most organisms are able to **sense** things in their surroundings. A rabbit, for example, is able to see and hear threats. This allows it to hop back quickly to its burrow. Many organisms respond to their surroundings by **moving**.

Organisms also need offspring. Rabbits can **reproduce** quickly: they can produce young several times a year. The young then **grow**. When they are mature, they can also reproduce. You can see life processes of an orang-utan in figure 2.

► **Fig. 2** Life processes in Sumatran orang-utans.



Some life processes take place all the time, such as breathing. Other life processes only occur relatively occasionally, such as reproduction. Life processes are usually easy to observe in humans and animals. They are often less easy to see in plants, though. Nevertheless, plants also carry out all life processes. You will learn more about that later.

2 Making drawings

In biology, we try to look at organisms as accurately as possible. The best way to do this is to make **drawings** of them. When you are drawing an organism, you must naturally look very closely at it.

Two different kinds of drawings are used in biology: true-to-life drawings and schematic drawings. You put in all the details as accurately as possible in a **true-to-life drawing** (see figure 3.2). In a **schematic drawing**, you leave out the details and only draw in the most important features (see figure 3.3).

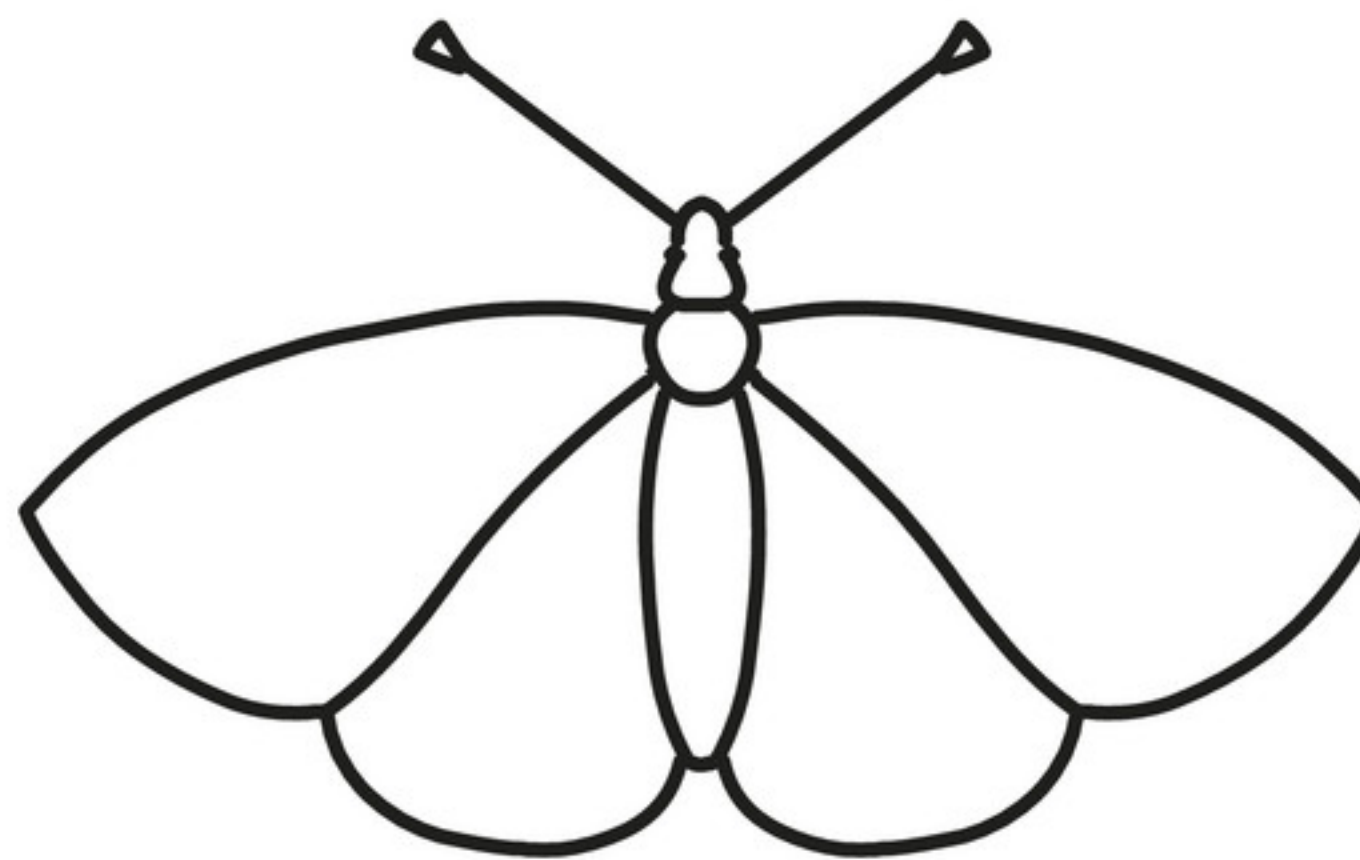
▼ **Fig. 3** Butterfly.



1 photo



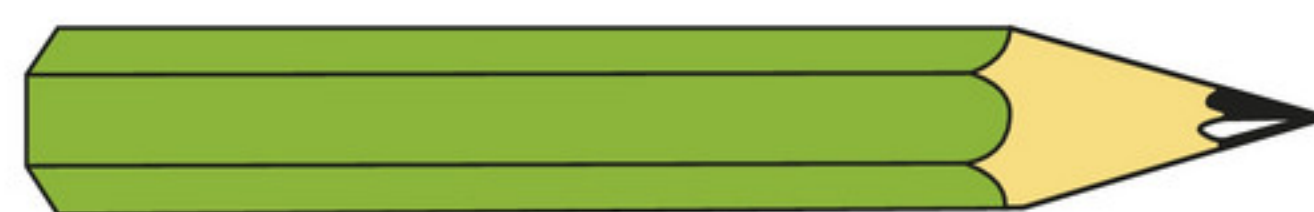
2 true-to-life drawing



3 schematic drawing

You can make a drawing of the outside or **external view** of an organism. You can also cut through an organism first before drawing it. There are various different ways of making such a section (see figure 4). In a **longitudinal section**, you cut the organism or object along its length. In a **cross section**, you cut the organism or object across its width.

▼ **Fig. 4** Pencil (schematic).



1 external view



2 longitudinal section



3 cross section

In a section, you only draw the surface of the cut, not any depth that you might see. Figure 5 lists the **drawing rules** that you should follow when making drawings in biology.

WB EXERCISES 4 TO 6, PAGE 8

▼ **Fig. 5** Drawing rules.

DRAWING RULES

- 1 Make large drawings. Do not put more than two or three drawings on the same page.
- 2 Use a pencil that is not too soft (e.g. HB).
- 3 If you add colours, use coloured pencils (not pens).
- 4 Draw the outline first in thin lines, and then add the various parts. You can make the lines clearer after that.
- 5 Draw what you see and not what your book says you ought to see.
- 6 Do not make your drawings too complicated.
- 7 Give your drawing a title, stating which organism or which part of an organism you have drawn.
- 8 If you are making a schematic drawing, include the word *schematic* in the title.
If you are drawing a section, state whether it is a *longitudinal section* or a *cross section*.
If you are drawing something that you have seen with a magnifying glass or a microscope, note down the *magnification*.
- 9 Add names to the parts you recognise. Place a horizontal line between a part and its name.
- 10 Work neatly!

▼ **Fig. 6** Crocodile.



3 Magnifying

In biology, we try to observe organisms ourselves as far as possible. That is not usually so difficult for plants, because we can **collect** plants. Remember that you must not do any harm to the environment, though.

Some animals are also easy for you to observe, such as pets, fish in aquariums or earthworms. The only way to study some other animals is in **pictures**.

Some organisms are so small that you cannot see them with the naked eye. You can then use a **magnifying glass** (see figure 7). The best kind to use are ones that have a magnifying power of about 10 times. You have to hold the magnifying glass close to your eye. The object you are looking at has to be brought up to the magnifying glass, until you see a clear image (see figure 8). If you want to study even smaller organisms, you can use a **microscope**. You will learn more about that in Unit 3.

▼ Fig. 7 Magnifying glasses.



▼ Fig. 8 Using a magnifying glass.



▼ Fig. 9 A dry bean.



A SEED

You can see young plants appearing in lots of places in the springtime. Most plants grow from **seeds** that germinate. One example of a seed is a **brown bean** (see figure 9).

There is a tough brown skin on the outside of a brown bean, its **seed coat**. The seed coat protects the seed. The white oval spot on a brown bean is called the **hilum**. The hilum is where the seed was attached to the parent plant. Figure 9 also shows a dark **heart-shaped bulge** under the hilum.

▼ Fig. 10 Bean seedling.



On the other side of the hilum, there is a very small hole in the seed coat. This pore is called the **opening**. A seed can absorb water quickly through the opening. Water is needed for the seed to germinate. The seed contains a **plant embryo**. When the seed germinates, a **seedling** starts to grow from the plant embryo (see figure 10).

4 Making tables and graphs

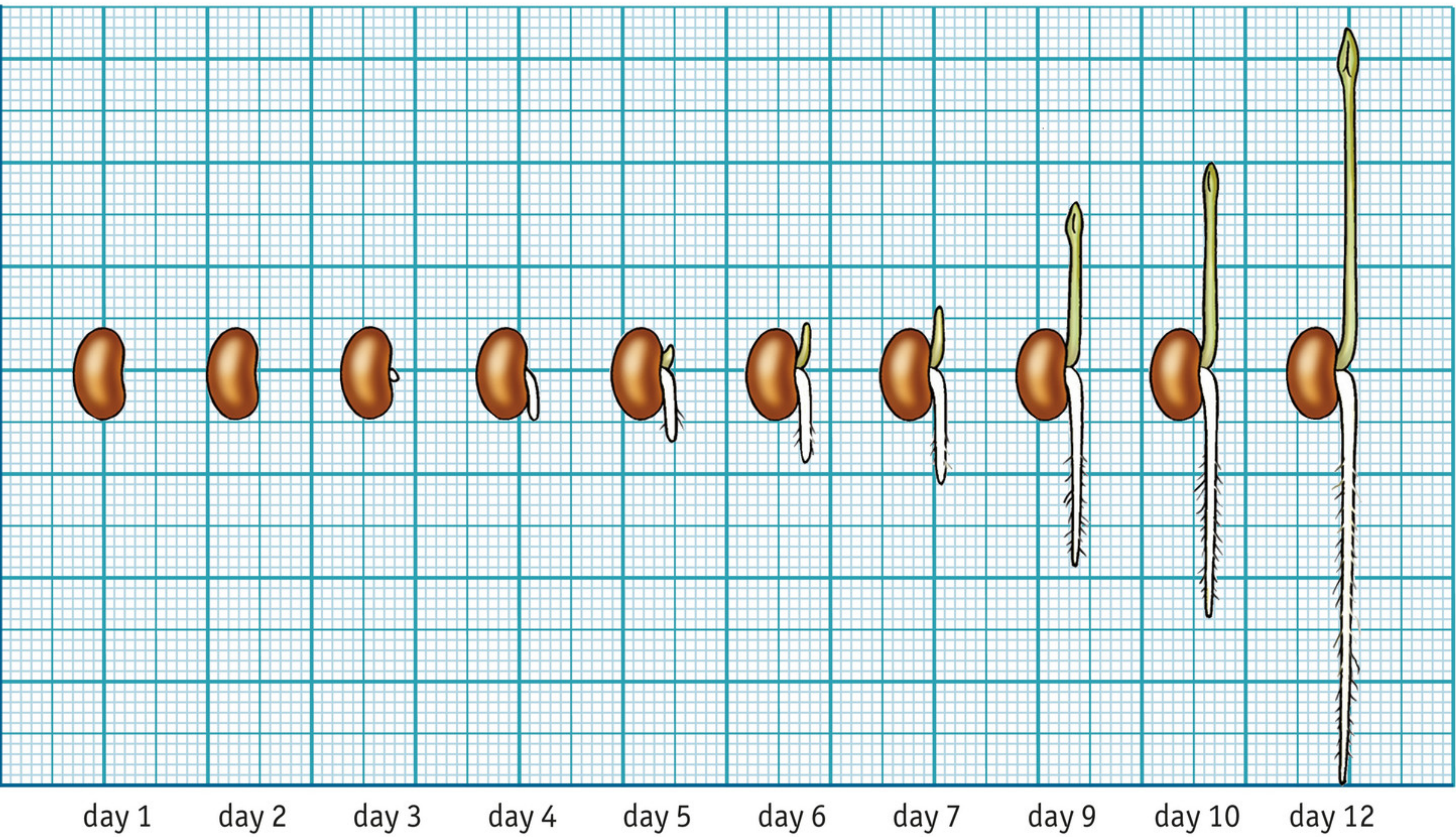
If you put a bean in a dish of water, it will germinate (see figure 11). The root comes out from the plant embryo first. The shoot then follows. Figure 12 shows you drawings of a germinating seed. Ten drawings have been made, on different days. You can measure the lengths of the root and shoot in each drawing. These measurements can be represented in a **table**.

WB EXERCISE 10, PAGE 14

▼ **Fig. 11** A germinating bean.



▼ **Fig. 12** The germination of a bean and the growth of the seedling.



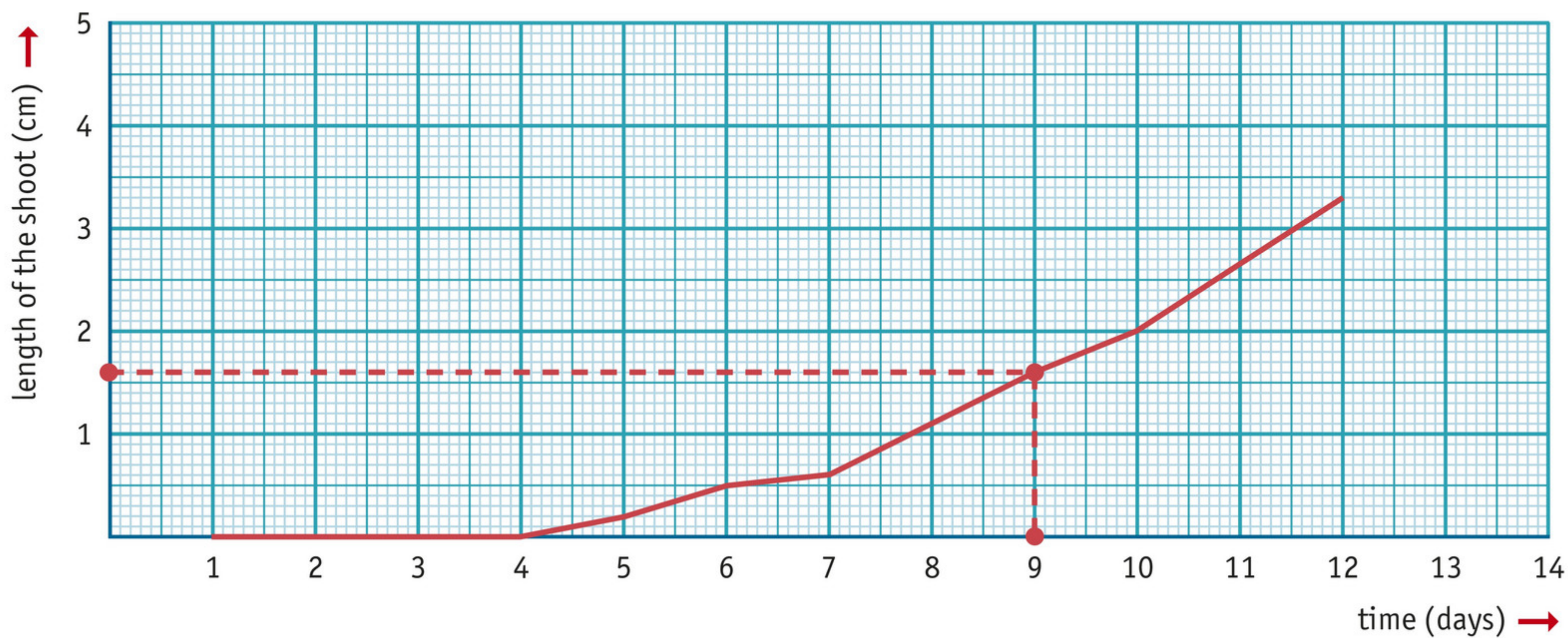
GRAPH

You can also represent the growth of the shoot and root in a **graph**. A graph has two axes. The horizontal axis is called the *x*-axis and the vertical one is the *y*-axis. In figure 13, the *x*-axis gives the number of *days*, and the *y*-axis gives the *length of the shoot*.

The length of the shoot on day 9 is shown as a point. The shoot was 1.6 cm long on that day.

WB EXERCISE 11, PAGE 14

▼ **Fig. 13** Graph showing the growth of a shoot.



5 Growth

During germination, a seedling becomes larger and heavier. Some plants can grow very fast (see figure 14). You too are larger and heavier than when you were a baby. In figure 15, you are told that children's growth is measured by a school doctor. Plants, animals and people all **grow**, just like all other organisms.

Growth is when an organism gets larger and heavier.

WB EXERCISE 12, PAGE 15

▼ Fig. 14 Bamboo.



1 young bamboo shoots can reach a height of 40 m in less than two months and can grow 1 m a day



2 stems of mature bamboo

▼ Fig. 15

School doctor

Hello. I'm Anne. I'm a school doctor, which means I examine the pupils' health. I work at primary and secondary schools. I see all the children at primary school. In secondary education, the pupils only come to see me if they have a question. I usually do a quick standard examination at the primary school. I weigh the children and measure their height. That lets you see whether a child is healthy and growing properly.



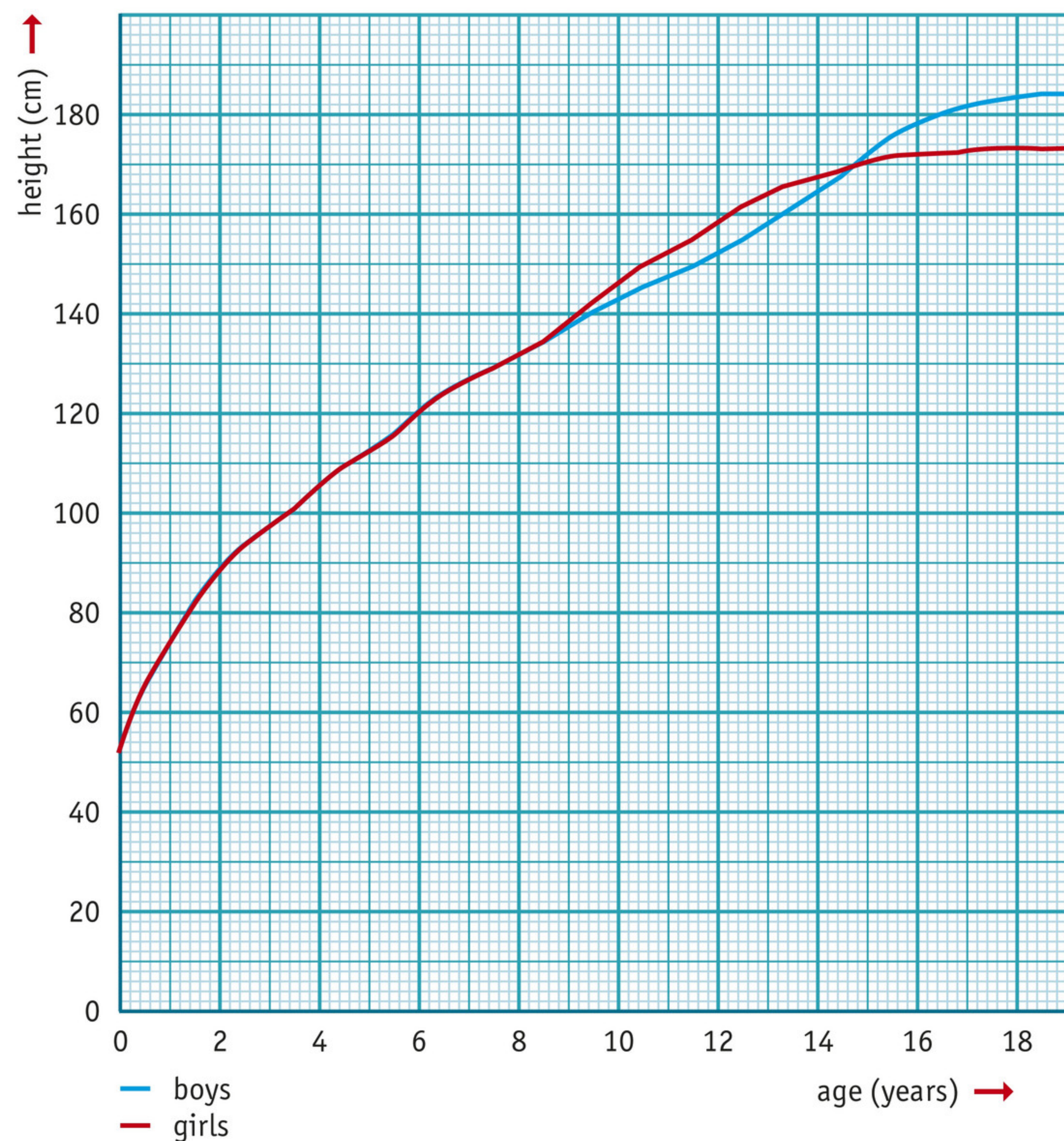
GROWTH SPURT

Figure 16 gives the **average** heights of boys and girls in the Netherlands. Many children are quite a bit taller or shorter than the average height.

The graph in figure 16 shows that children do not grow equally quickly all the time. The number of centimetres you grow in a year is called the **growth rate**. Particularly during the first year of life (age 0 to 1), you grow very fast. A period of rapid growth is called a **growth spurt**.

Many children also have a growth spurt lasting around two years at about 12 years of age (at puberty). On average, this second growth spurt starts earlier in girls than in boys.

▼ **Fig. 16** Graph showing the average heights of boys and girls in the Netherlands.

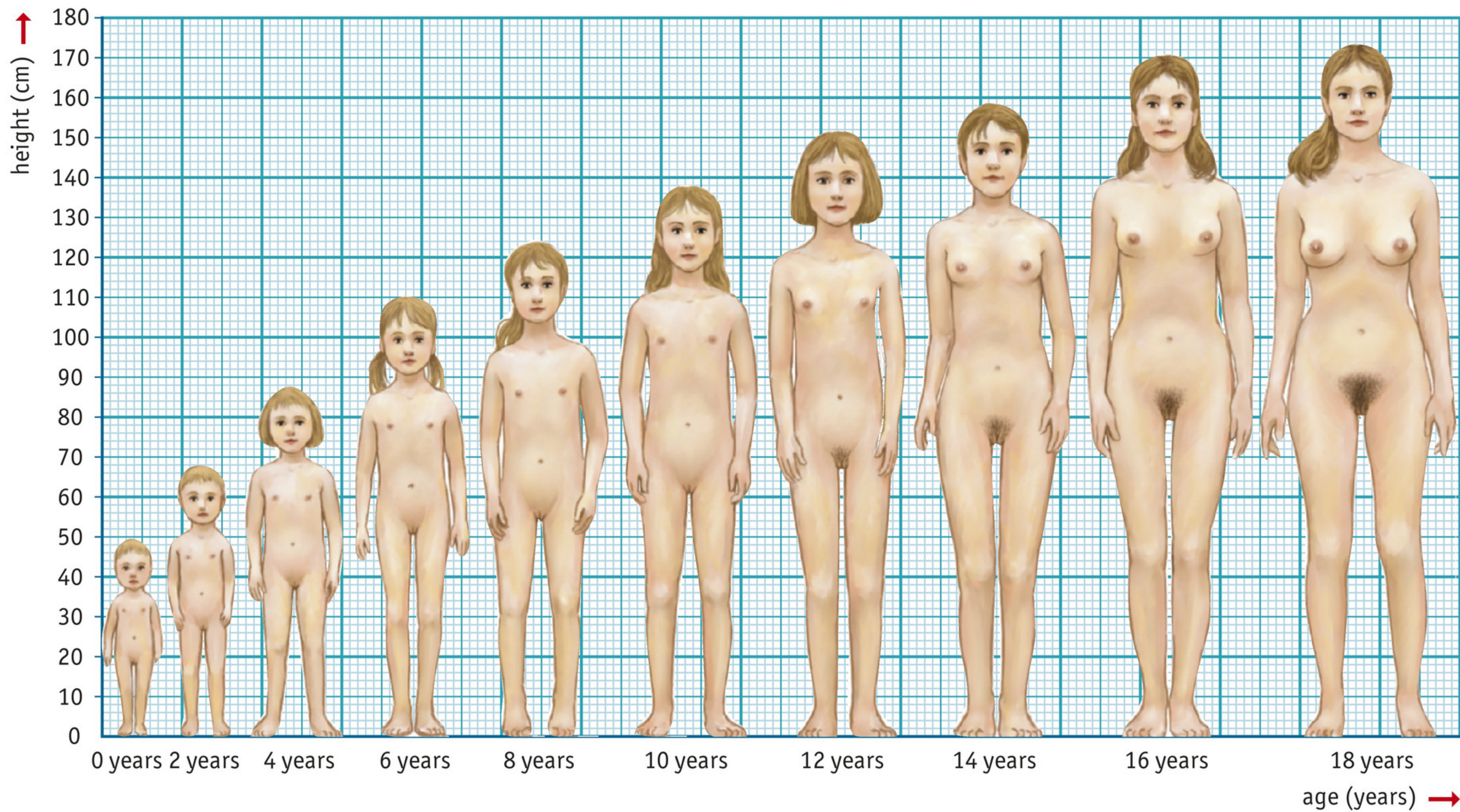


GROWTH OF PARTS OF THE BODY

The growth in height in humans is related to the growth of the skeleton. The various parts of the skeleton do not grow equally quickly. Figure 17 shows the growth of a girl. It shows you how quickly the different parts of the body grow.

WB EXERCISES 13 TO 15, PAGE 15

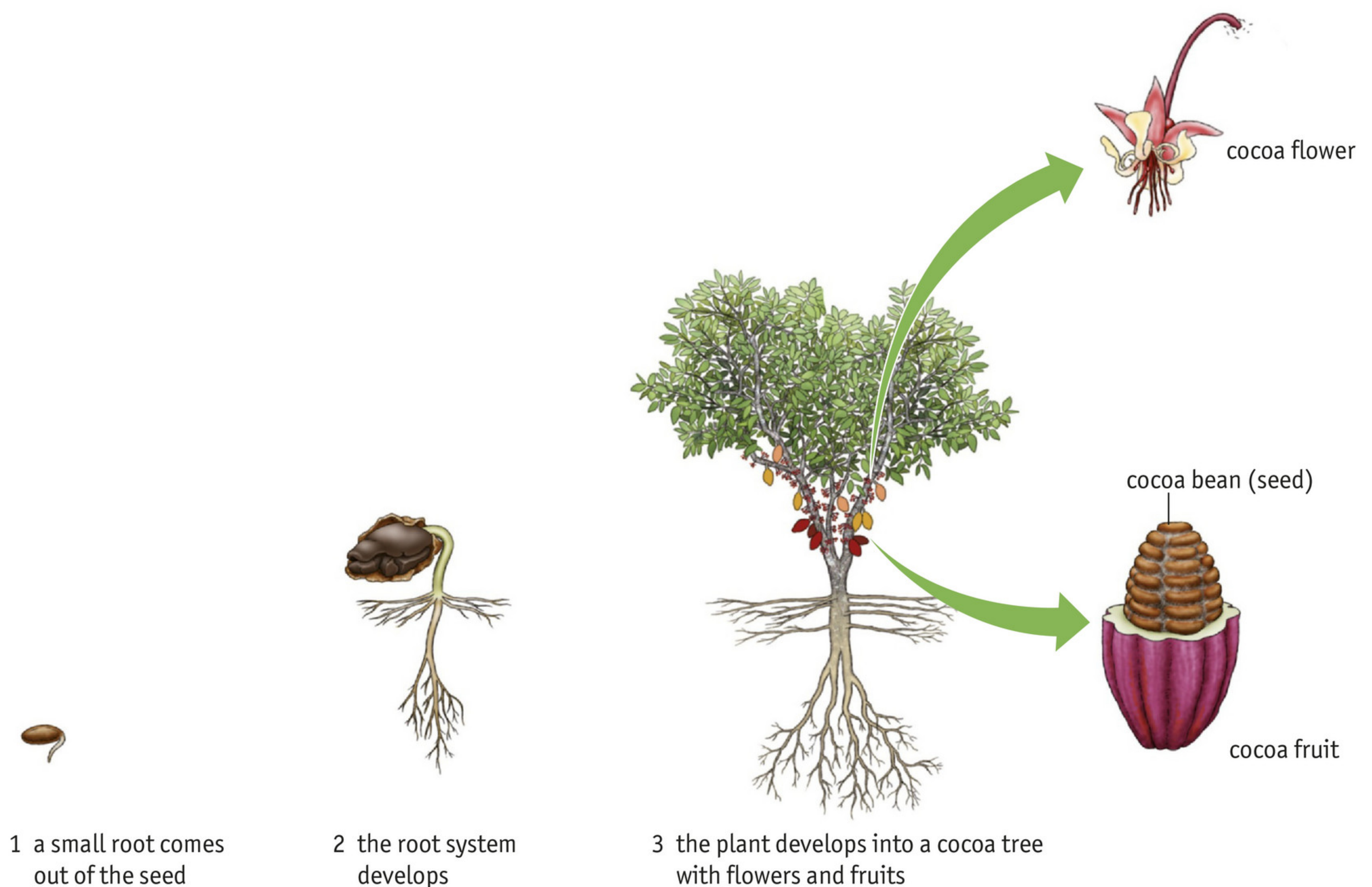
▼ Fig. 17 Growth of a girl.



6 Development

Changes take place as a seedling grows. The root becomes more and more branched. New organs can also appear. Leaves form on the stem, for example, and sometimes buds, flowers and fruit as well (see figure 18). All these changes are called **development**. Development takes place as animals and humans grow too, not only in plants. **Development means that the structure of an organism changes.** The changes allow organs to work better. Sometimes new organs may appear.

▼ **Fig. 18** Development in a cocoa plant.



DEVELOPMENT IN ANIMALS

Growth and development occur in animals too. Figure 19 shows you a penguin egg, the chick and the adult animal. A great deal of development takes place inside the egg. The chick is therefore already well developed by the time it hatches. This means that the body structure of the chick is already very similar to that of the adult penguin. You can see that the chick does still have a lot of growing to do: it becomes bigger and heavier.

WB EXERCISE 16, PAGE 18

▼ **Fig. 19** Growth and development in a penguin.



METAMORPHOSIS

In some groups of animals, the young do not resemble the adult animals at all. Examples of that are frogs and butterflies. In these animals, we refer to the young as **larvae**. Before they can become mature, the larvae must undergo a complete change of form called **metamorphosis**. There is not merely a change in body structure, but also in the way the animals live. In figure 20 you can see that the larva of a ladybird looks completely different from the adult insect. The larvae also eat different food and cannot fly like the adult animals do.

▼ **Fig. 20** Two stages from the life cycle of a ladybird.



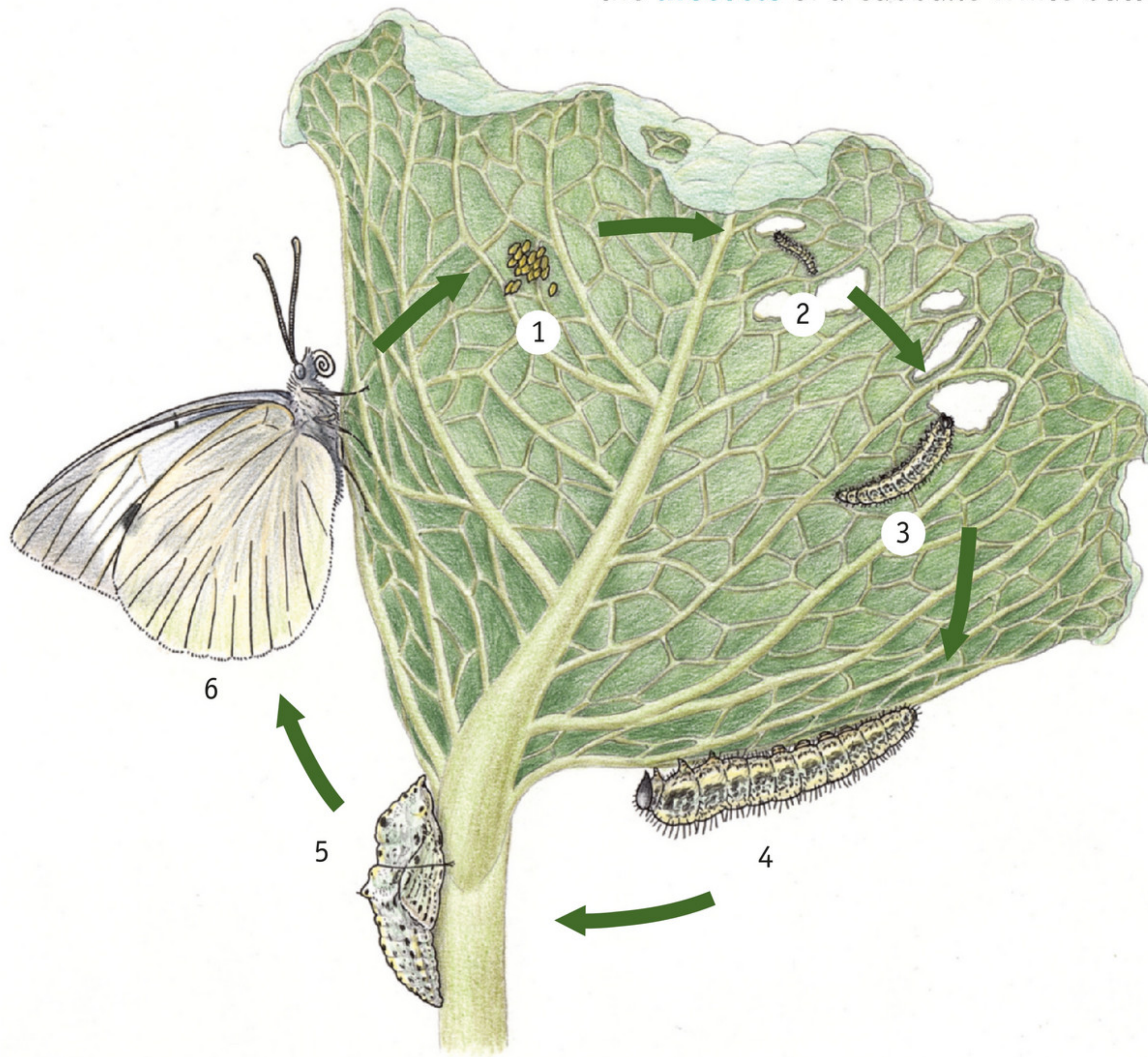
1 larva



2 adult animal

▼ **Fig. 21** The life cycle of a Cabbage White butterfly.

Metamorphosis also occurs in butterflies. We are going to take the **Cabbage White butterfly** as an example. Cabbage White butterflies are white butterflies (see figure 21). There are four phases in the lifecycle of a Cabbage White butterfly (egg, larva, pupa and imago). Together, these stages make up the **lifecycle** of a Cabbage White butterfly.



- 1 A Cabbage White butterfly lays eggs on cabbage leaves.
- 2 A small caterpillar comes out of the egg.
- 3 The caterpillar eats a lot. The caterpillar grows fast when it sheds its skin.
- 4 The caterpillar makes a cocoon around itself.
- 5 The pupa does not eat and it does not grow either. Inside the cocoon, the body of the caterpillar changes into that of a butterfly.
- 6 The adult stage (imago) of the butterfly comes out of the pupa. A butterfly does not grow. A butterfly is able to reproduce

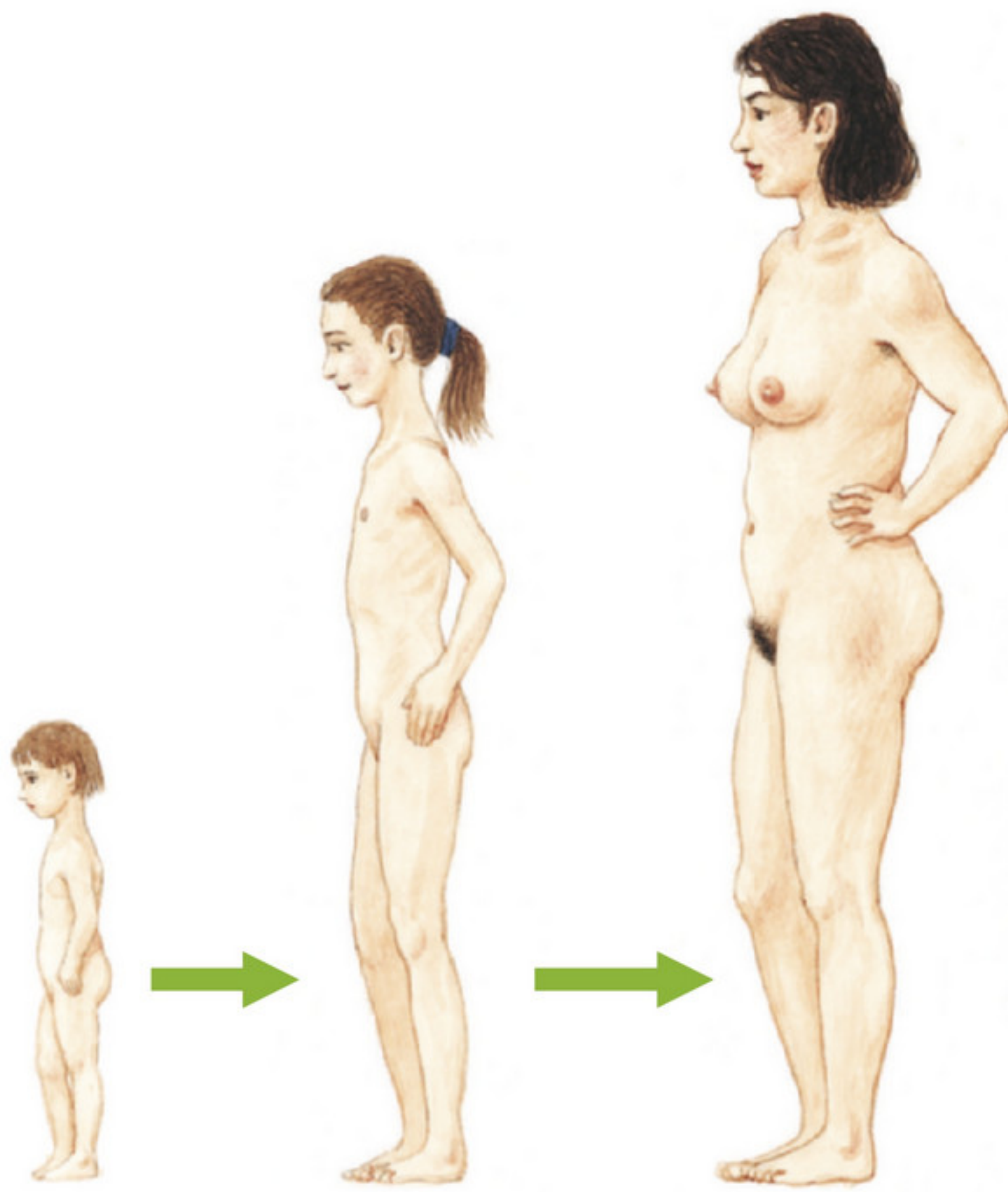
Cabbage White butterflies often lay their **eggs** on cabbage leaves. After a few warm days, the larvae emerge from the eggs. The larvae of butterflies are called **caterpillars**. The caterpillars eat the cabbage leaves. This allows them to grow.

Insects have hard armour protecting their bodies. This outer armour cannot grow. Caterpillars therefore have to **shed their skin** several times. When this happens, the hard armour breaks open and the caterpillar crawls out of the opening. The caterpillar then makes a new, larger layer of armour. It takes a little while before the new armour hardens. During that period, the caterpillar can grow quickly. After each skin is shed, the caterpillar starts eating again. Eventually the caterpillars stop eating. They then look for a quiet spot, where they stiffen up and make a casing around their bodies. This is called **pupation**. The casing around them is called a **cocoon**. A pupa (or chrysalis) does not eat and generally does not move either. Major internal changes take place during the pupal stage. All sorts of new organs appear, such as wings, large eyes and reproductive organs.

After two to three weeks, the pupa breaks open and a mature butterfly emerges. After a few hours, the butterfly is able to fly off. The adult insect stage is known as the **imago**.

These four stages (egg, larva, pupa and imago) appear in other insects as well, such as beetles, bees, flies and wasps.

▼ Fig. 22 Growth of a girl.



▼ Fig. 23 Children learn to play games on the Internet at an early age.



HUMAN DEVELOPMENT

You have learned that changes in the structure of an organism are called development. As you grow, changes also take place in your own body. In humans, this is called **physical development**. Figure 22 shows how the body of a child develops into that of an adult.

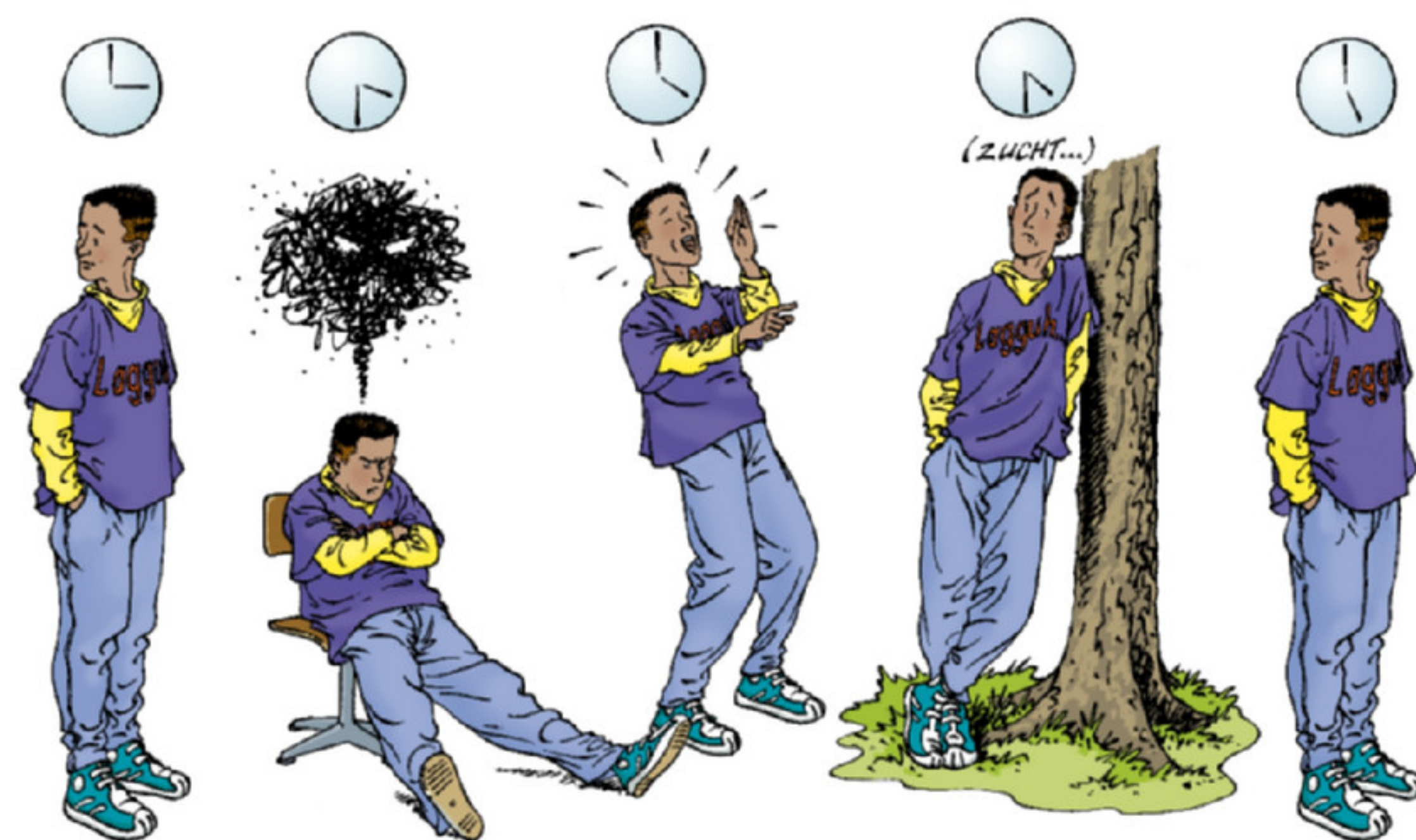
In humans, **mental development** also takes place. This is the development of intelligence, emotion and personality. Various different **stages of life** can be seen in humans as they develop physically and mentally.

A young child that is not yet able to walk is called a **baby**. For most children, this phase lasts about one and a half years. A baby is entirely dependent on the people around it. Children of about 1 to 3 years of age are called **toddlers**. Babies and toddlers learn a great deal, such as talking and moving. For example, they learn how to walk or build a tower. Learning to move is called **motor development**. Children aged 3 to 5 are known as **pre-schoolers**. These young children learn how to play games on the Internet, how to ride a bicycle, draw, and play with other children, for example (see figure 23).

Children aged 6 to 12 are **schoolchildren**. At school, a child learns to read and write, for example, and to do arithmetic. Children aged 12 to 16 are **adolescents** or teenagers. A lot of physical development takes place during **puberty**. The internal reproductive organs start to work, for example, and girls start to develop breasts. Your emotions change a lot and your mood can swing a great deal (see figure 24). You think a lot about yourself and the contacts that you have with others. Sometimes you fall in love with somebody. A person aged about 16 to 21 is a **young adult**. During this phase, people learn to be fully independent.

As an **adult**, you are entirely independent. Many adults have children. This phase lasts until about age 65. After this phase, adults are also known as the **elderly** (**senior citizens**). The elderly often suffer from physical problems and discomforts as they get older. This means that they need care and assistance.

► Fig. 24



The various stages of life do not last equally long in all people. Some children develop quickly and others more slowly. The ages stated for each phase are therefore only *average* ages.

7 Main themes in biology

▼ **Fig. 25** An animal moving is an example of self-regulation.



Important topics in biology are self-regulation, self-organisation, interaction, reproduction and evolution. These are also referred to as ‘main themes’. We will keep coming back to these topics in other *Your Biology* units. The various topics are explained below.

SELF-REGULATION

Organisms can control a lot of things themselves. They regulate their breathing, they feed themselves and they move spontaneously. This is known as **self-regulation**. Self-regulation allows organisms to survive. Organisms can recover from injuries and can defend themselves against intruders that cause diseases, such as bacteria. In order to stay alive, organisms take in food. Animals must be able to move if they are to survive (see figure 25). Organisms are able to regulate all these things for themselves.

SELF-ORGANISATION

In figure 26.1 you can see a poppy seed, seedling and mature plant. Each part of the poppy has its own task. The roots take up water. The leaves make food for the plant and the seeds develop from the flowers. The poppy is therefore well organised: each part has its own fixed position – the flowers above, the stem and leaves in the middle and the roots underneath, in the soil. When a poppy grows from a seed, it can organise itself into a mature plant with flowers, leaves and roots. This is known as **self-organisation**. Self-organisation can be seen in other organisms as well. In figure 26.2, you can see this in a peregrine falcon. A chick develops from an egg and then grows into an adult animal. Each part of the body is in the correct place and can carry out specialised tasks. The eyes, for instance, let it see and the wings can be used for flying.

▼ **Fig. 26** Self-organisation in growth and development.



seed

1 in a plant



2 in an animal

▼ Fig. 27 Interaction.



1 a python eating a rat



2 a cock fight

▼ Fig. 28 Reproduction in toads.



INTERACTION

Organisms respond to one another. You can see examples of this in figure 27. Animals eat other animals. Two cocks fight each other to see who will 'rule the roost'. Organisms also respond to their surroundings. A duck will for example start swimming when it gets into the water. Flowers open when the sun rises. The surroundings also affect organisms. A swallow migrates in autumn to warmer regions and an earthworm will crawl away out of direct sunlight. We say that organisms interact with their surroundings. These responses of organisms to each other and to their surroundings are known as **interaction**.

REPRODUCTION

You have learned that reproduction is one of the life processes. All organisms reproduce to create new organisms. These offspring grow and develop until they reach the mature or adult stage. The offspring often closely resemble their parents (see figure 28). A blackbird lays an egg that develops into a new blackbird: an example of the life process known as **reproduction**. You will learn more about reproduction next year.

EVOLUTION

Figure 29.1 shows you some common snails, all belonging to the same species. The snails look very much alike, but you can still see differences among them. This is known as **variation**. There are for example both lighter and darker snails. In an area where the ground is dark-coloured, a dark snail will be less easy to see. The darker ones are better camouflaged and birds will therefore not find the dark snails as quickly as the light-coloured ones. The birds select the light-coloured ones. This **selection** means that there will be fewer light-coloured snails (see figure 29.2). The offspring of the dark snails will then survive better and have offspring of their own. This means that there will be more and more dark snails in that area. Over the course of time, the snails will have changed. After a hundred years, the snails may have changed not only in colour but also perhaps in shape. A great deal can change over the course of millions of years. A particular species of snail may disappear altogether or new snail species may appear. The development of life on Earth, with species appearing, changing and/or disappearing, is known as **evolution**. You will learn more about evolution next year.

WB EXERCISES 23 AND 24, PAGE 23

► Fig. 29 Evolution through variation and selection.



1 variation



2 selection

8

Biology in professional life

Many professions need you to know a bit about biology. In some professions this is very obvious – professions that are involved with **nature** and the **environment**, for instance.

There are numerous professions that involve **caring** for people, animals or plants. To do these jobs properly, you must know a lot about people, animals or plants. Nursing home staff, for example, must know the symptoms of illness in the elderly. A salesman in a pet shop must know what food animals need if they are to stay healthy.

There are also professions that are specifically involved in **combating disease** in humans, animals or plants. Naturally, you must also know a lot about people, animals or plants for these professions.

There are other jobs where it is not immediately obvious that biology is involved. These jobs are often only about one specific aspect of biology, for instance **nutrition**, **movement**, **reproduction**, the **skin** or the **senses**. Somebody whose job is to create meals must know about healthy food. Someone who fits contact lenses must understand about eyes and eye abnormalities. Other subjects are often also important in these professions. You can see a few examples of professions that are related to aspects of biology in figure 30.

Finally, there are also professions that involve providing **information** and **education**.

▼ **Fig. 30** Professions that use aspects of biology.

WB EXERCISE 25, PAGE 25



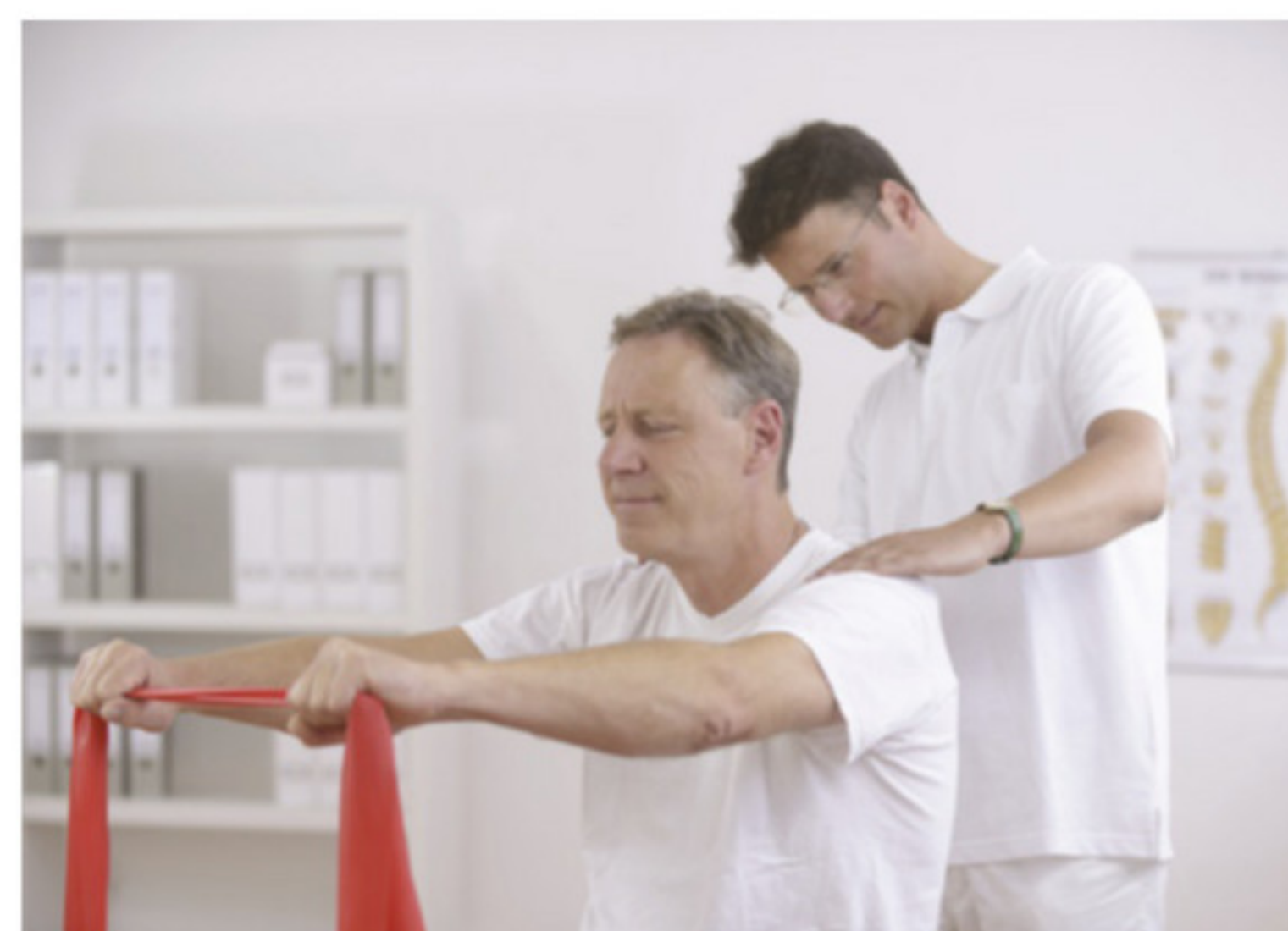
1 a zookeeper looks after animals



2 a surgeon performs operations



3 a grower looks after plants



4 a physiotherapist helps muscle injuries to recover



5 an optometrist measures the eyes



6 a dental hygienist gives information about caring for your teeth

9 The life cycle of a common frog

In Basics 6, you learned that metamorphosis takes place in some animals. Frogs are one group that also undergo metamorphosis. We shall take the **common frog** as an example. There are various phases in the life cycle of a common frog. These are shown in figure 31.

▼ **Fig. 31** The lifecycle of a common frog.



- 1 Adult frogs mate.
- 2 Frogs' eggs (frogspawn).
- 3 A newly hatched tadpole. It has external gills on its head.
- 4 Tadpole with internal gills.
- 5 Metamorphosis starts. The tadpole grows back legs.
- 6 The tadpole grows front legs. The tail becomes smaller.
- 7 The gills have disappeared and lungs have developed inside the body.
- 8 The tail has disappeared. The tadpole has become an adult frog.

Common frogs mate in the spring. You may see the eggs – **frogspawn** – in ponds or ditches. Each single clump of frogspawn is laid by one female frog. The clump may contain up to three thousand eggs. Each egg is surrounded by a layer of jelly. Within this jelly, the egg develops into a small larva (see figure 32).

A point is reached when the larva can wriggle out of the jelly. For a frog, this larval stage is known as a **tadpole**. A tadpole is about 6 mm long. It has feather-like structures on the sides of its head called the **external gills** (see figure 32). The tadpole uses its gills to get oxygen from the water. It can also get oxygen from the water through its **skin** (particularly the tail). A tadpole mostly eats algae.

▼ **Fig. 32** Growth and development in the common frog.

external gill



After about three weeks, the tadpole is 10 to 13 mm long. The tail has grown a lot. The external gills disappear and are replaced by **internal gills**. Two small back legs can already be seen.

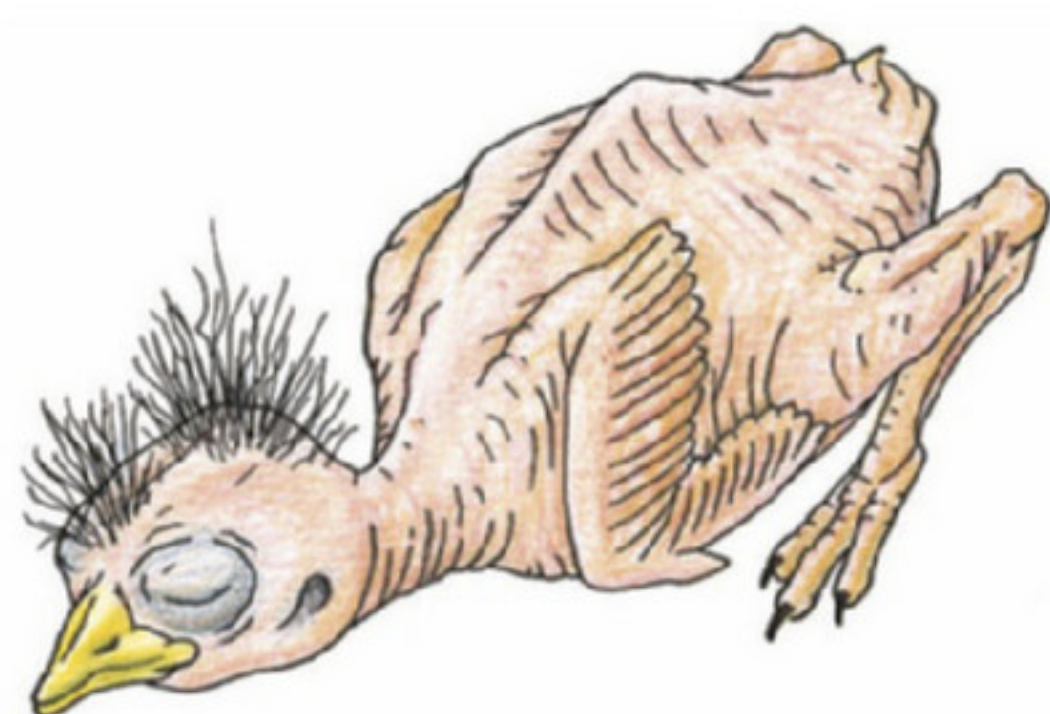
After 8 to 9 weeks, a tadpole is about 35 mm in length. The front legs slowly start to develop. The tail begins to shorten.

After 12 to 13 weeks, the animal already looks like a frog, although it is a small frog about 15 mm long. Its mouth has become much larger. The frog starts eating insects. **Lungs** have developed in the meantime as well. This means that the frog is now also able to live on land. A frog takes up oxygen from the air using its lungs and through its skin.

WB EXERCISES 26 TO 28, PAGE 26

10 Young that stay and young that go

▼ Fig. 33 Birds.



1 altricial (blackbird)



2 precocial (lapwing)

You may perhaps have seen a nest of young birds. The young were probably naked and helpless in the nest. Birds that are helpless after hatching are said to be **altricial**. Altricial birds are blind during the first few days after hatching. They do not have feathers yet and cannot stand on their own legs (see figure 33.1). Altricial birds remain in the nest for a number of weeks and are cared for by the parents. The young of all songbirds stay in the nest for some time after hatching.

There are other types of birds whose young leave the nest very soon after hatching. They can see as soon as they hatch and they can walk around just an hour or so later. They are covered in downy feathers (see figure 33.2). The scientific word for birds that leave the nest is **precocial**. The young of birds that live and brood on the ground or on water do not usually remain in the nest.

The fact that precocial chicks are further developed when they hatch does not necessarily mean that they mature more quickly than altricial chicks. A duckling is very soon able to look for food itself, for instance, whereas a blackbird chick has to be fed by its parents for a few weeks. The young blackbird grows so fast, however, that it will have developed further than the duckling by the time it is a few weeks old. When the young blackbird leaves the nest a couple of weeks later, it can already fly. The duckling can only do that much later. Young blackbirds have already long become independent while the ducklings are still swimming round after their mother.

There are also differences in how far mammals are developed at birth. Mammals are animals such as mice or dogs where the young drink milk (suckle) from the mother. They often have fur. New-born mice are helpless and blind (see figure 34.1) and mice are therefore also altricial animals. In the wild, mice make nests in a burrow, for example underground or beneath a fallen log. The baby mice are not as well developed when they are born as some other mammals, such as a giraffe (see figure 34.2). A baby giraffe is able to stand just five minutes after it is born and it is capable of following its mother around shortly after that. A giraffe does not make a nest and a baby giraffe is already well developed when it is born. Giraffes are therefore precocial animals.

WB EXERCISES 29 AND 30, PAGE 28

► Fig. 34 Mammals.



1 altricial (mouse)



2 precocial (giraffe)

Summary

OBJECTIVE 1

You must be able to describe what biology is. You also need to be able to distinguish between things that are living, dead or non-living (never alive).

- Biology is the study of life.
 - In biology, we study organisms (living things).
- We refer to something as being alive if it carries out life processes.
- We say that something is dead if it no longer carries out life processes.
 - Something that is dead was once alive.
- We refer to something as non-living if it was never alive at all.

OBJECTIVE 2

You must be able to name the seven life processes.

- Life processes that are related to taking in and getting rid of substances:
 - Breathing.
 - Feeding.
 - Excreting.
- Life processes that are related to responding to the surroundings:
 - Sensing (sight, hearing, touch, smell, taste).
 - Moving.
- Life processes that are related to obtaining offspring:
 - Reproducing.
 - Growing.

OBJECTIVE 3

You must be able to tell the difference between true-to-life and schematic drawings and whether a picture is an external view, a longitudinal section or a cross section.

- True to life: all details are given as accurately as possible.
- Schematic: only the most important features are shown. The details have been left out.
- Outside view: as the organism appears when viewed from the outside.
- Section: only the surface of the section is drawn.
 - Longitudinal section: as the organism appears if it is cut along its length.
 - Cross section: as the organism appears if it is cut across its width.

OBJECTIVE 4

You must be able to name the parts of a bean and say what they look like and what they are for. You must also be able to recognise these parts in other seeds.

- Seed coat: the brown skin around the bean.
 - The seed coat protects the seed.
- Hilum: the white spot where the seed was attached to the parent plant.
- Opening: an opening in the seed coat.
 - The seed absorbs water through the opening during germination.
- Heart-shaped bulge.
- Two seed leaves (pale yellow).
 - The seed leaves contain the food store.
- Plant embryo: includes the root and shoot.
 - When the seed germinates, the plant embryo grows into a seedling.

OBJECTIVE 5

You must be able to read a table showing the growth of an organism and make your own table.

- Two or more columns:
 - in the left-hand column: time (e.g. the number of days);
 - in the columns next to it: the length or weight of the organism.

OBJECTIVE 6

You must be able to read and make a graph showing the growth of an organism.

- A graph has two axes:
 - The x-axis (horizontal axis).
Time is plotted along the x-axis (e.g. the number of days).
 - The y-axis (vertical axis).
The length or weight of the organism is plotted along the y-axis.

OBJECTIVE 7

You must be able to describe what growth and development are. You must also be able to describe growth in humans.

- Growth: when an organism gets larger and heavier.
- Development: when changes take place in the structure of an organism.
 - The changes allow organs to work better.
 - New organs may appear.
- A human keeps growing taller until about age 18.

- A period of rapid growth is called a growth spurt.
 - Growth is most rapid in the early years of life.
 - There is also a growth spurt at puberty.
- Not all parts of the body grow equally quickly:
 - the legs grow fastest;
 - the head grows least quickly.

OBJECTIVE 8

You must be able to name the different types of development in humans and list the stages of life with their average ages and characteristics.

- Three types of development in humans:
 - Physical development: changes in the body.
 - Motor development: learning to move.
 - Mental development: developing intelligence, emotion and personality.
- Each stage of life does not last equally long in all people.
 - The ages stated for each stage are only average.
- Baby: from 0 to 1½ years.
 - A baby is entirely dependent on the people around it.
- Toddler: from 1½ to 3 years.
- Pre-schooler: from 3–5 years.
- Schoolchild: from 6–12 years.
 - Mental development, e.g. reading, writing and arithmetic
- Adolescent: from 12–16 years.
 - Major physical changes take place, e.g. the reproductive organs start working and girls start to develop breasts.
 - Changes in feelings about other people.
- Young adult: from 16–21 years.
 - Young adults become fully independent.
- Adult: from 21–65 years.
- Elderly (senior citizens): over 65.
 - Many elderly people need care and assistance.

OBJECTIVE 9

You must be able to describe what metamorphosis is. You must also be able to describe the lifecycle of a Cabbage White butterfly and other animals that undergo a metamorphosis.

- Metamorphosis: a young animal has a very different body structure and way of life than the adult.
 - The immature animal is called a larva

- There are four stages in the lifecycle of a Cabbage White butterfly: egg → caterpillar → pupa → butterfly.
- Caterpillar (larva).
 - A caterpillar eats a lot.
 - A caterpillar sheds its skin several times.
 - A caterpillar grows quickly just after shedding its skin.
- Pupa.
 - The animal is inside a casing (the cocoon).
 - A pupa does not eat.
 - A pupa does not usually move.
 - Major internal changes take place (e.g. the development of wings).
- Imago (adult butterfly).
 - A butterfly does not eat much.
 - A butterfly can fly.
 - A butterfly is able to reproduce.

OBJECTIVE 10

You must be able to name the main themes of biology and recognise them in examples.

- Self-regulation: organisms control e.g. their own breathing and movement, helping them to survive.
- Self-organisation: organisms can organise themselves as they grow and develop.
- Interaction: organisms respond to each other and to their surroundings.
- Reproduction: organisms can reproduce to make copies of themselves. This creates new organisms.
- Evolution: the development of life on Earth in which species appear, change and/or disappear.
 - Evolution is driven by variation and selection.

OBJECTIVE 11

You must be able to name professions in which biology plays a role.

- Professions that are related to nature and the environment.
 - E.g. forest warden.
- Professions that are related to caring for people, animals or plants.
 - For people: e.g. nurse.
 - For animals: e.g. livestock farmer.
 - For plants: e.g. gardener.
- Professions that are related to combating disease.
 - For plants: e.g. tree surgeon.

- Professions that use specific aspects of biology.
 - E.g. dietician (for human nutrition), sports instructor, obstetrician, beautician, optometrist.
- Professions which involve providing information and education.
 - E.g. biology teacher.

EXTRA OBJECTIVE 12

You must be able to describe the lifecycle of a common frog.

- Three stages in the lifecycle: egg → tadpole → frog.
- Egg.
 - Frogspawn: a clump of frogs' eggs in a pond.
- Tadpole.
 - A tadpole only lives in water.
 - A tadpole breathes with gills and through the skin.
 - A young tadpole has external gills but an older tadpole has internal gills.
 - A tadpole eats algae.
 - A tadpole uses its tail to move around.
- Metamorphosis:
 - The tail becomes smaller and disappears;
 - Back legs appear first, then front legs;
 - The mouth becomes larger;
 - The gills disappear and lungs develop.
- Frog.
 - A frog lives in water and on land.
 - A frog breathes with its lungs and through the skin.
 - A frog eats insects.
 - A frog uses its back legs to move around.

EXTRA OBJECTIVE 13

You must be able to name the characteristics of altricial animals and precocial animals.

- Altricial animals are often naked, helpless and blind shortly after being born.
 - They stay in the nest for a few weeks, looked after by their parents.
 - When they leave the nest, birds are able to fly and mammals able to run.
- Precocial animals have feathers or fur and can see as soon as they are born.
 - They are able to follow their parents independently within a few hours of being born.
 - Birds may only be able to fly after a few months.
- Precocial animals are further developed when they are born than altricial animals, but they develop more slowly after being born than altricial animals do.

SKILLS AND COMPETENCIES**BASICS**

- You have learned how to make drawings that follow the drawing rules.
- You have learned how to use a magnifying glass.
- You have learned how to measure the heights of your classmates.
- You have learned how you calculate averages.

EXTRA

- You have practiced using the Internet and reference material.

The diagnostic test does not include any questions about these skills and competencies.

You have met a school doctor and a veterinarian in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

Answer the questions below.

- 1 What is biology?
- 2 Is a pickle from a jar living, dead or non-living?
- 3 Is a robot living, dead or non-living?

Figure 35 shows an ostrich egg and a panda.

- 4 Is the panda alive, dead or non-living?
- 5 When can you say that the ostrich egg is alive?

▼ Fig. 35



1 ostrich egg

2 panda

OBJECTIVE 2

In figure 36 you can see four life processes in parrots and parakeets.

- Write down which life process belongs with numbers 1 to 4.
- State after number 5 a life process that you have not yet named and which is about getting offspring.
- State after number 6 two other life processes that you have not yet named and that are about the uptake and elimination of substances.

▼ Fig. 36



1 a cockatiel with a chick

2 a macaw flying away



3 a lory looking at a rat



4 a parrot eating seeds

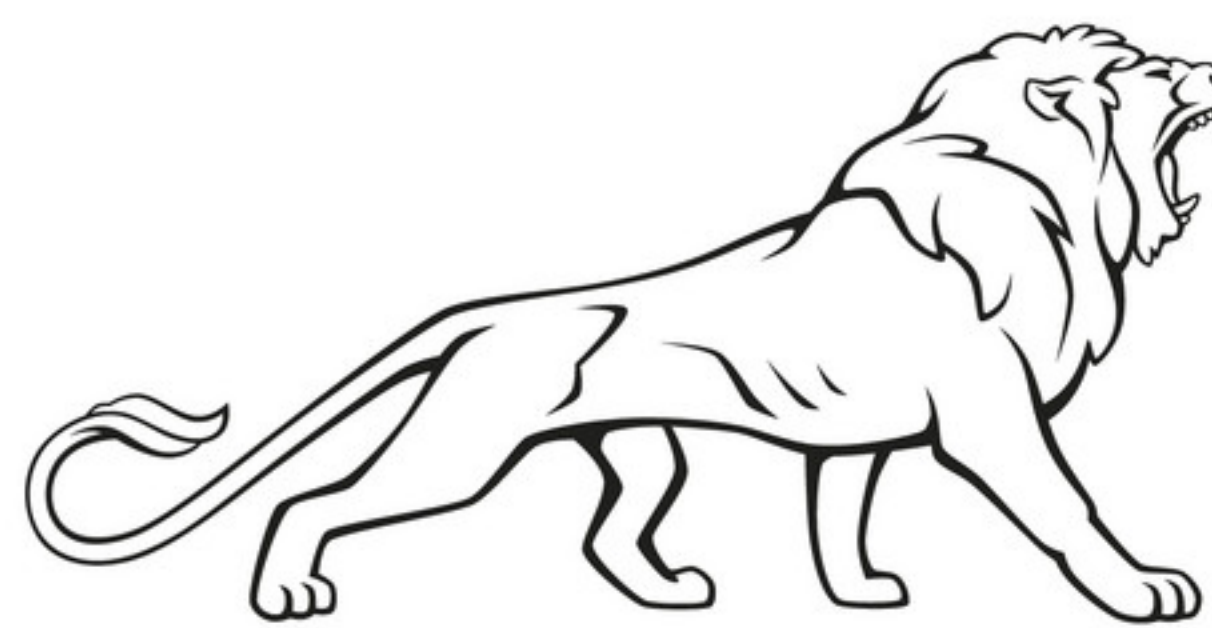
OBJECTIVE 3

Say whether each of the following statements is true or false.

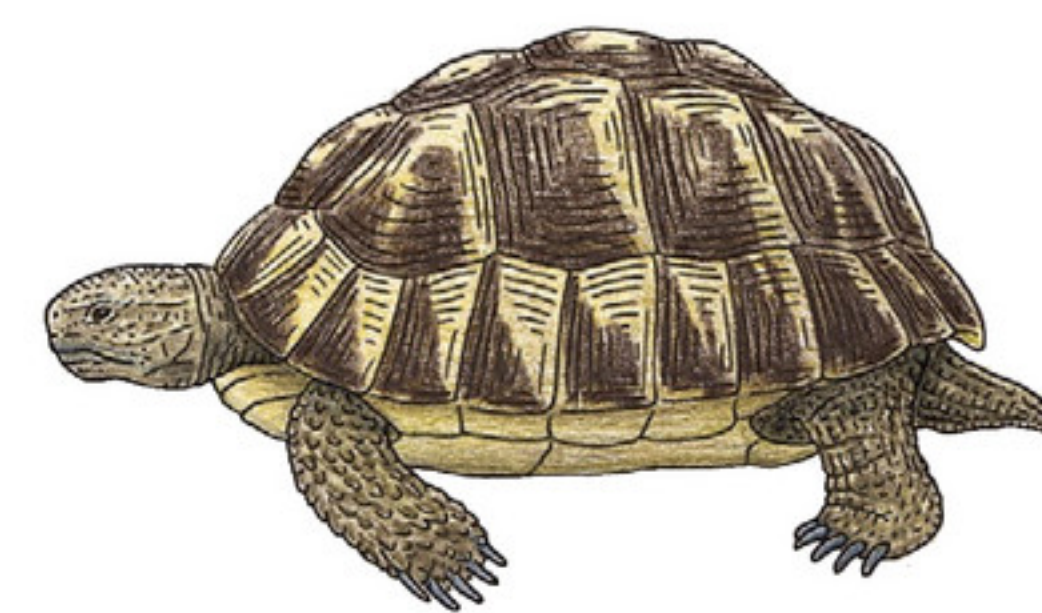
There are four drawings in figure 37.

- 1 Drawing 1 is a true-to-life drawing of a lion.
- 2 Drawing 2 is a cross section through a tortoise.
- 3 Drawing 3 is a longitudinal section through a tortoise.
- 4 Drawing 4 is a cross section through a tortoise.

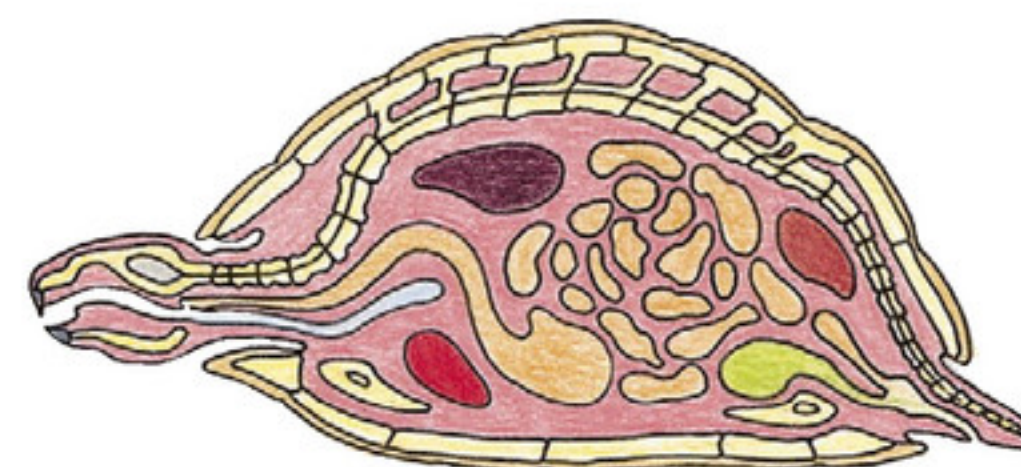
▼ Fig. 37



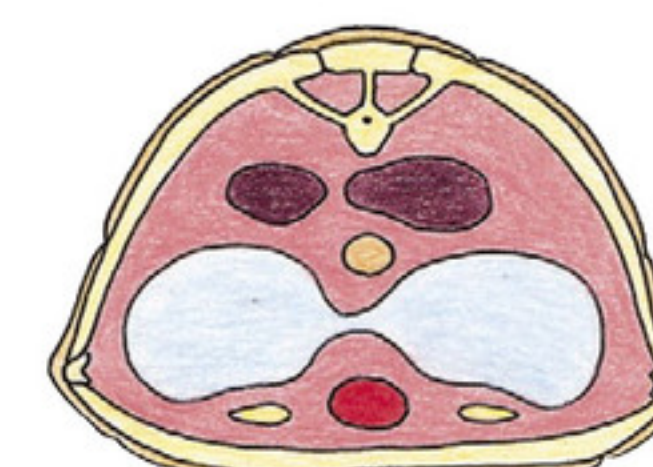
drawing 1



drawing 2



drawing 3



drawing 4

OBJECTIVE 4

Answer the questions below.

Figure 38 is a drawing of a brown bean.

- 1 What is the name for parts 4 and 5 together?
- 2 Which number is the part that protects the seed?
- 3 What is the function of part 1?
- 4 What is the function of part 6?

▼ Fig. 38

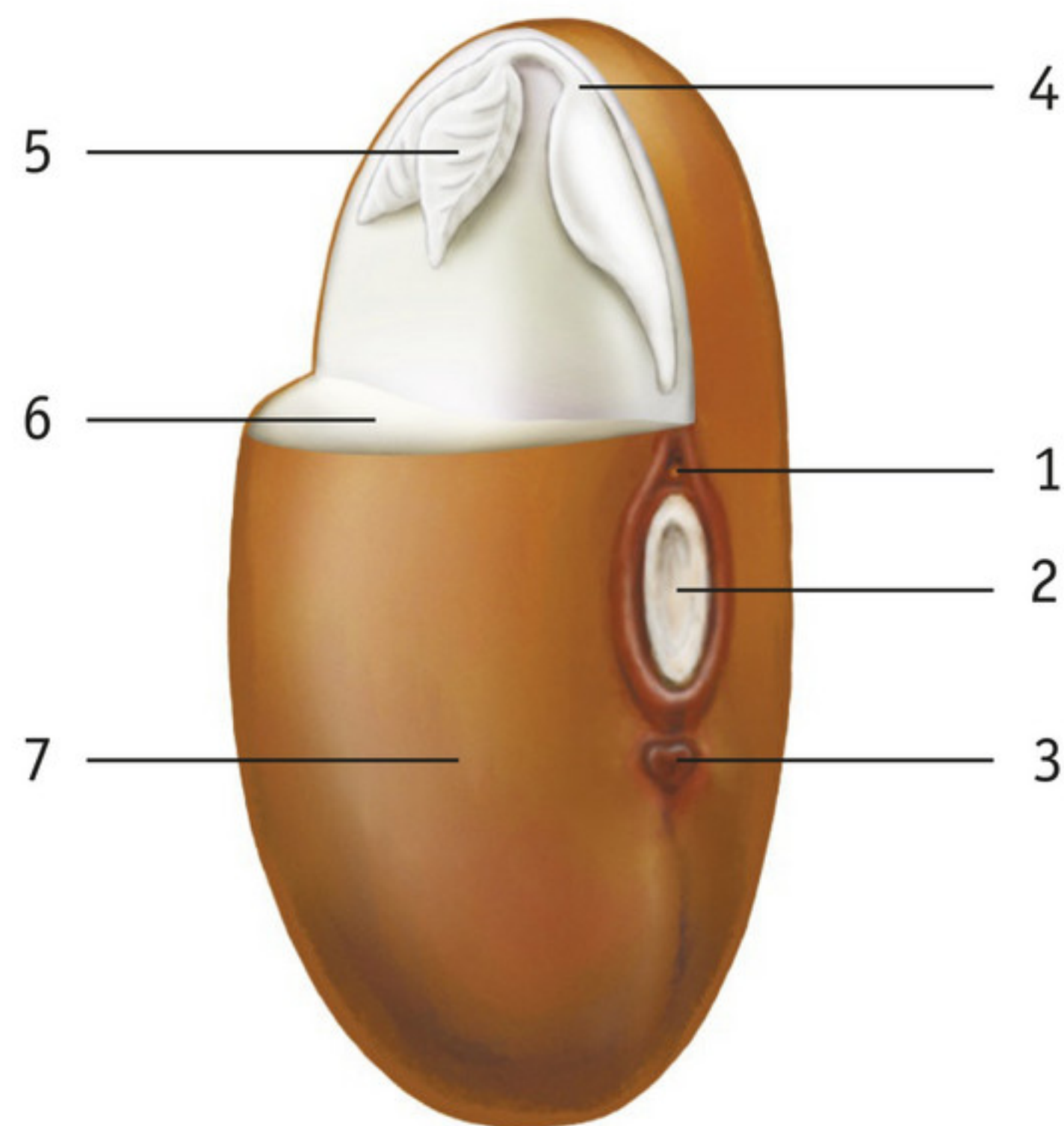


Figure 39 shows a horse chestnut.

The chestnut used to be attached by part P.

- 5 What is the name for part P?

▼ Fig. 39



OBJECTIVE 5

Figure 40 shows a boy at various ages.

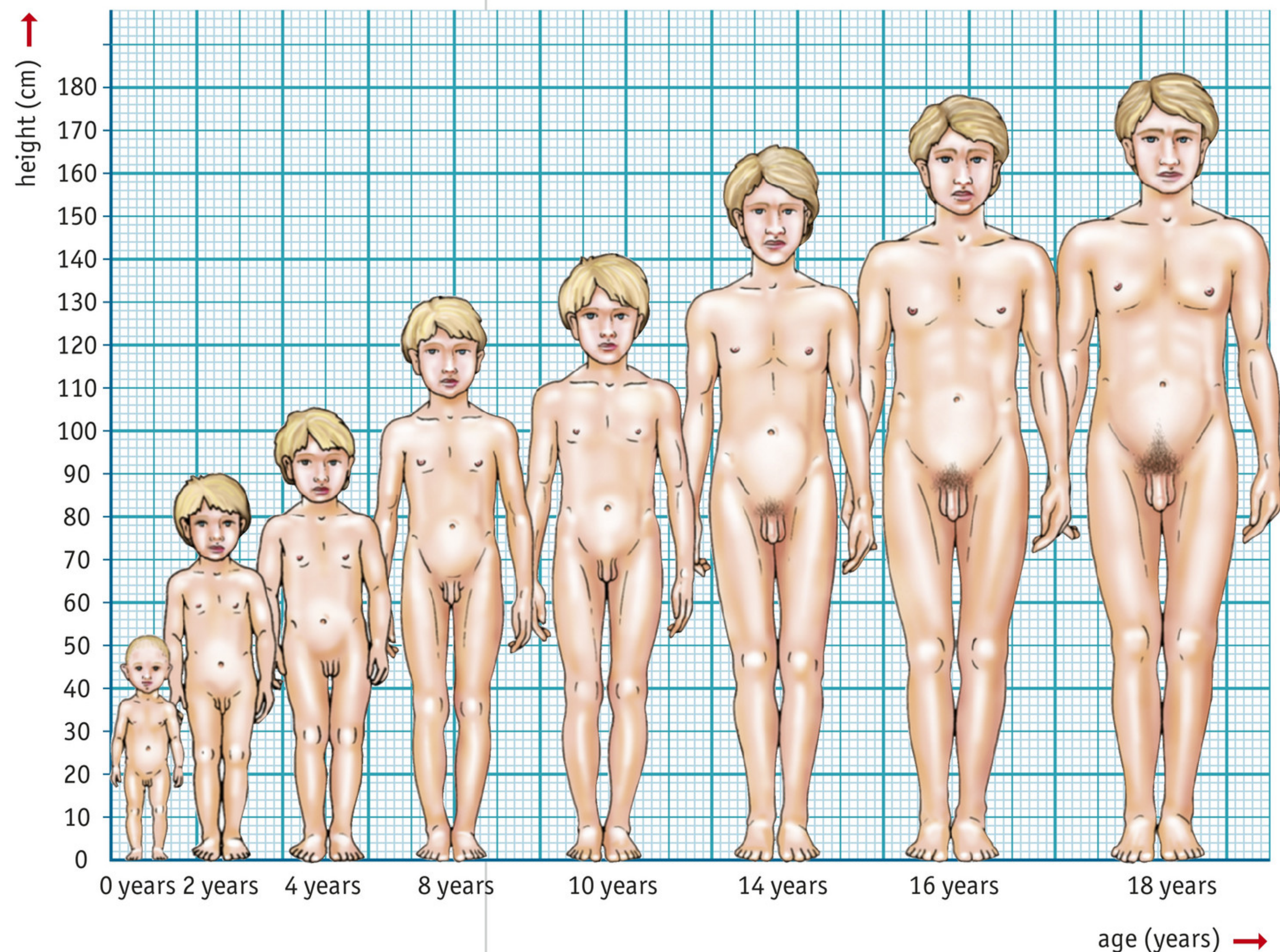
- Read off the height of each figure.
- Use this data to complete the table in your workbook.

OBJECTIVE 6

Your workbook has graph paper.

- Draw a graph on it showing the growth of the boy in figure 40.

▼ Fig. 40



OBJECTIVE 7

Answer the questions below.

Figure 41.1 shows a young eagle-owl. Figure 41.2 shows the same owl a year later.

- 1 How can you see that the owl has grown?
- 2 And how can you see that the owl has developed?
- 3 Steven is 8 years old. For roughly how many more years will he continue to grow?
- 4 Has Steven already had a growth spurt?
- 5 Which grows more quickly in humans: the legs or the head?

▼ **Fig. 41** Eagle-owl.



1 owl chick 2 the same owl a year later

OBJECTIVE 8

Answer the following multiple choice questions.

- 1 What term do we use for someone who is aged 18?
 - A Adolescent.
 - B Young adult.
 - C Adult.
- 2 When do the reproductive organs start working?
 - A In adolescents.
 - B In young adults.
 - C In adults.
- 3 Figure 42 is a photo of a three-year-old boy. What term do we use for the stage of life that this boy is currently at?
 - A Baby.
 - B Toddler.
 - C Pre-schooler.
 - D Schoolchild.

▼ **Fig. 42**



- 4 Young children often learn to play games on the Internet.

What kind of development is this?

- A Only mental development.
 - B Only motor development.
 - C Only physical development.
 - D Both mental and motor development.
- 5 During which stage of life do you learn to ride a bicycle? And what kind of development is this?

<i>Stage of life</i>	<i>Type of development</i>
A pre-schooler	physical development
B schoolchild	physical development
C pre-schooler	motor development
D schoolchild	motor development

OBJECTIVE 9

Answer the following multiple choice questions.

- 1 What is metamorphosis?
 - A When young animals have a completely different body structure and way of life than mature animals.
 - B When young and mature animals become larger and heavier.
 - C When more new organs are added as the organism grows.
 - D When an organism's organs start working better.

- 2 Figure 43 shows you four stages in the lifecycle of a beetle called a nut weevil. During which stage does metamorphosis take place? And during which stage is the animal able to reproduce?

	<i>Metamorphosis during</i>	<i>Reproduces during</i>
A	stage 1.	stage 3.
B	stage 1.	stage 4.
C	stage 2.	stage 3.
D	stage 2.	stage 4.

▼ Fig. 43



stage 1



stage 2



stage 3



stage 4

- 3 What is the correct order for the developmental stages of a Cabbage White butterfly?
- A Egg → pupa → caterpillar → imago.
 B Egg → caterpillar → pupa → imago.
 C Pupa → egg → imago → caterpillar.
 D Caterpillar → egg → imago → pupa.
- 4 During which stage is a Cabbage White butterfly inside a cocoon?
- A As an egg.
 B As an imago.
 C As a pupa.
 D As a caterpillar.

- 5 Three of the developmental stages of a Cabbage White butterfly are the imago, pupa and caterpillar. During which of these stages does the most growth occur? And which sees the most development?

*Most growth
as*

- A an imago.
 B an imago.
 C a caterpillar.
 D a caterpillar.

*Most development
as*

- a pupa.
 a caterpillar.
 an imago.
 a pupa.

- 6 Three stages from the life cycle of a Cabbage White butterfly are shown in figure 44. In which of these stages does a Cabbage White butterfly eat most? And in which stage does it eat least?

*A Cabbage White
butterfly eats most in*

- A stage 1.
 B stage 2.
 C stage 3.
 D stage 3.

*A Cabbage White
butterfly eats least in*

- stage 2.
 stage 3.
 stage 1.
 stage 2.

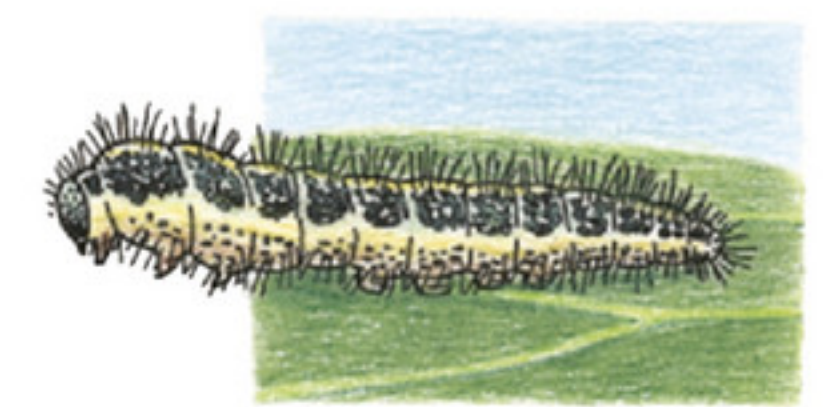
▼ Fig. 44 Cabbage White butterfly.



stage 1



stage 2



stage 3

OBJECTIVE 10

Statements 1 to 5 are about figure 45.

Which main theme of biology fits in best with each statement?

Choose from: *evolution – interaction – reproduction – self-organisation – self-regulation*. Use each term once.

- The mother animal produces new young moorhens.
- A complete moorhen chick develops from the egg in three weeks.
- The moorhen chicks are able to move on their own.
- One year later, only the quickest of the four chicks is still alive.
- The pike and the moorhen chick respond to one another.

▼ Fig. 45 Moorhen and chicks.

**OBJECTIVE 11**

Say whether each of the following statements is true or false.

- 1 Nursing professions require a knowledge of biology.
- 2 Biology is important in professions that are about combating diseases.
- 3 A dietician knows about reproduction in animals.
- 4 An obstetrician knows about obesity and weight problems.
- 5 A gardener's job is looking after plants.
- 6 An optometrist's job is about human nutrition.

EXTRA OBJECTIVE 12

Answer the questions below.

Figure 46 shows three animals.

- 1 What does animal 1 eat?
- 2 Which animal or animals undergo a metamorphosis?
- 3 Which animal loses its gills?
- 4 Which of these animals can breathe through its skin?
- 5 Which legs appeared first in animal 2 – the front legs or the back legs?

Tadpoles can breathe using two different types of gills.

- 6 What type of gills does animal 1 use?
- 7 Does animal 3 eat other animals? Explain your answer.

▼ Fig. 46



animal 1

animal 2

animal 3

EXTRA OBJECTIVE 13

Answer the questions below.

We can classify birds and mammals into two groups: altricial and precocial.

- 1 To which group does the new-born hamster in figure 47.1 belong?
- 2 To which group does the newly hatched duckling in figure 47.2 belong?
- 3 In which group do the young become mature first?
- 4 Which group do ground-nesting birds mostly belong to?
- 5 The young of some mammals and birds can be naked, helpless and blind.
Explain why these young animals still have a good chance of survival.

▼ Fig. 47



1 new-born hamster

2 newly-hatched duckling

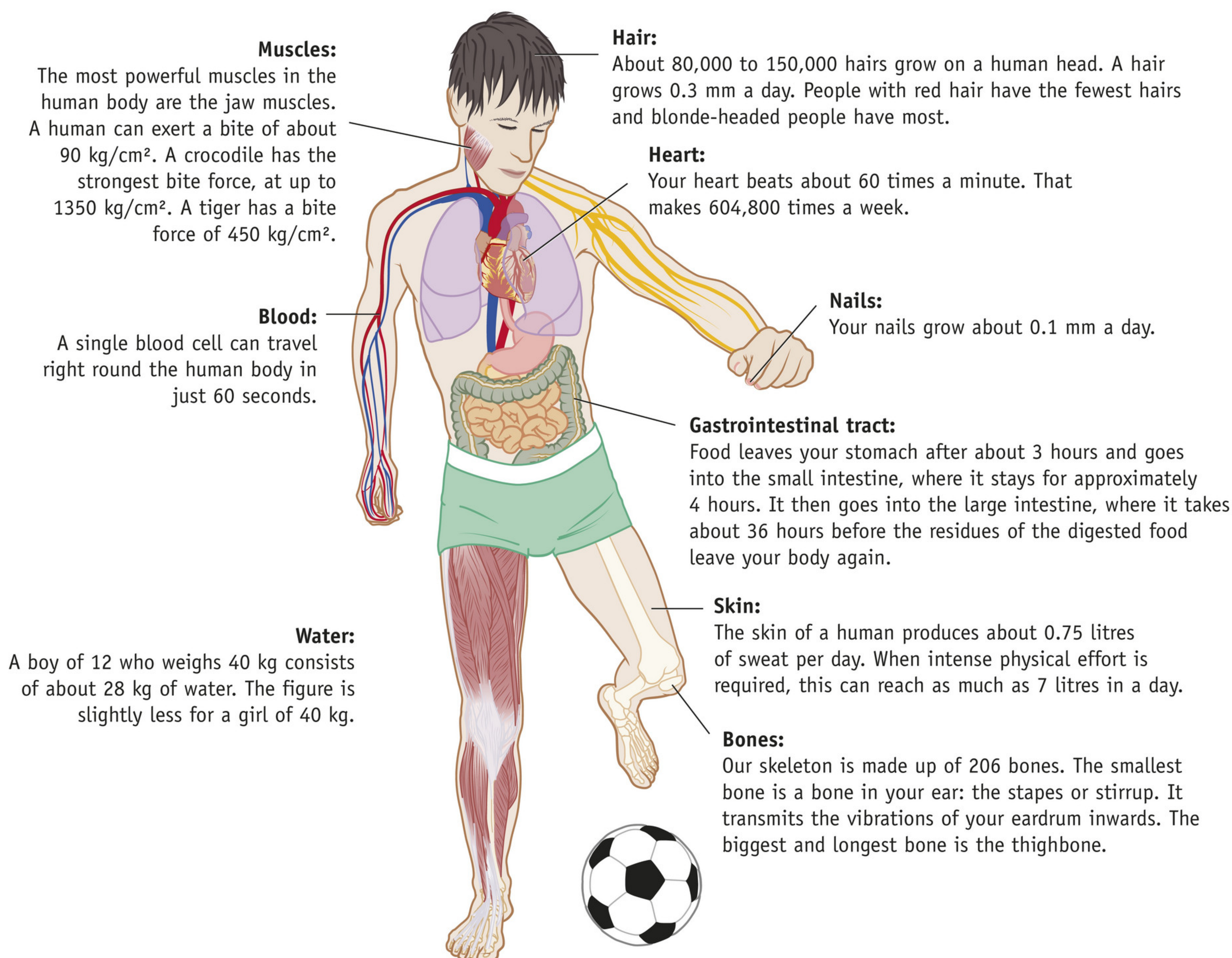
You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three parts. You can do the exercises for them in your workbook. Your teacher will tell you how many parts you should choose.

1 The human body in numbers

Figure 48 gives you all kinds of numbers about the human body. You are going to use them to do some calculations. You can for example read how much your hair grows in a day; you can then work out how much it grows in a year.

WB EXERCISE 1, PAGE 31

▼ Fig. 48



2 Cats and dogs

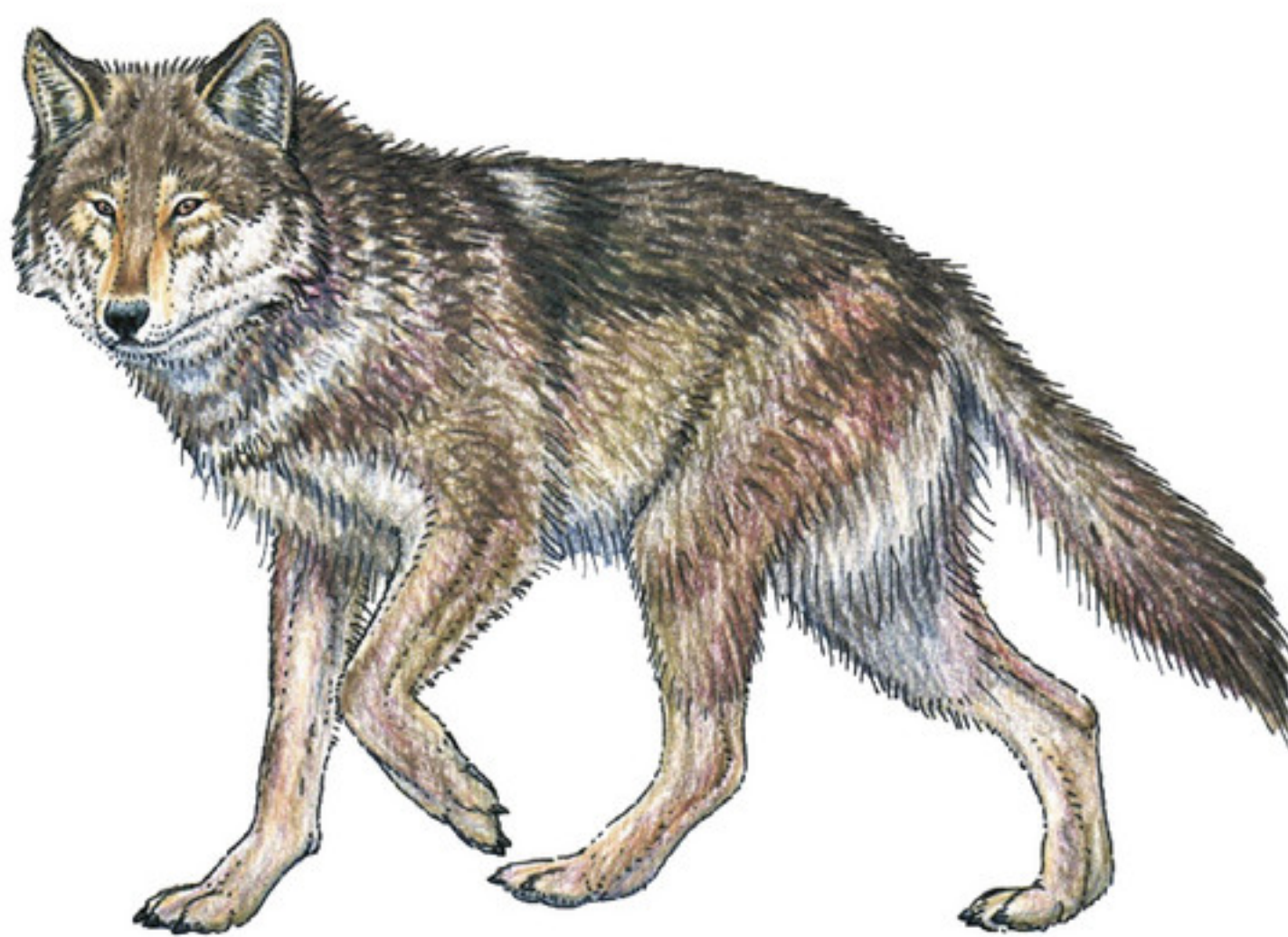
▼ Fig. 49 Wild cat.



Many people in the Netherlands have a cat and/or a dog as a pet. In this extension, you are going to compare cats and dogs. You have to fill in a table. People were already keeping cats and dogs as pets 7000 years ago. Domestic cats are probably descendants of wild cats (see figure 49). Our cats are therefore very similar to wild cats. There are other species in nature that also look very similar to the domestic cat. These species are related to the cat. The dog is a descendant of wolves (see figure 50). Some breeds of dog look very like wolves. There are other species in nature that are related to the dog.

WB EXERCISE 1, PAGE 32

▼ Fig. 50 Wolf.



▼ Fig. 51 Animal species that are related to cats or dogs.



lynx



jackal



hyena

3 Man – woman – child

We can divide humans into men, women and children. The males, females and young of many animals have special names. In this extension, you are going to use the Internet or reference books to look up these names. You have to fill in a table.

WB EXERCISE 1, PAGE 34

► Fig. 52 Chickens.



1 female



2 male



3 young

2 Plants



BASICS

- 1 The lifecycle of a plant
- 2 Roots
- 3 Stems
- 4 Leaves
- 5 Edible roots, stems and leaves
- 6 Designing an experiment

EXTRA

- 7 Twigs
- 8 Leaf morphology

40
45
47
51
55
57

59
61

SUMMARY AND DIAGNOSTIC TEST

- Summary
- Diagnostic test

EXTENSION

- 1 Sprouts and shoots
- 2 The importance of photosynthesis
- 3 Insect galls

63
66

72
73
75



This unit is called 'Plants'. Most plants have roots, stems and leaves. Many plants also have flowers and seeds. You have already worked with a seed in the previous unit. In this unit, you will learn how a seed germinates. You will also learn what the roots, stems and leaves are for and, in the case of edible plants, which of these parts you can eat. In this unit, you will get to know a tomato grower and you will learn that growing and cultivating plants is important for human nutrition. Biology often involves research. You will also learn how to do research in this unit. You will learn how to write a report of a research study or experiment too.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 The lifecycle of a plant

▼ Fig. 1 Snack vegetables.



You can find snack vegetables in more and more places now (see figure 1). Maybe you can get them at school too. Eating enough vegetables and fruit keeps you healthier. You do not become ill so easily and they are not fattening. Many sweets are made largely out of sugar but a bowl of snack vegetables is often just as popular as a jar of sweets. Children often prefer sweet tastes to vegetables and fruit, which may be healthier but are not so sweet. This gave a number of tomato growers the idea of trying to cultivate sweet vegetables and fruit (see figure 2). To be able to do this well, you need to know a lot about how plants grow.

▼ Fig. 2 Tomatoworld in Honselersdijk.

Grower

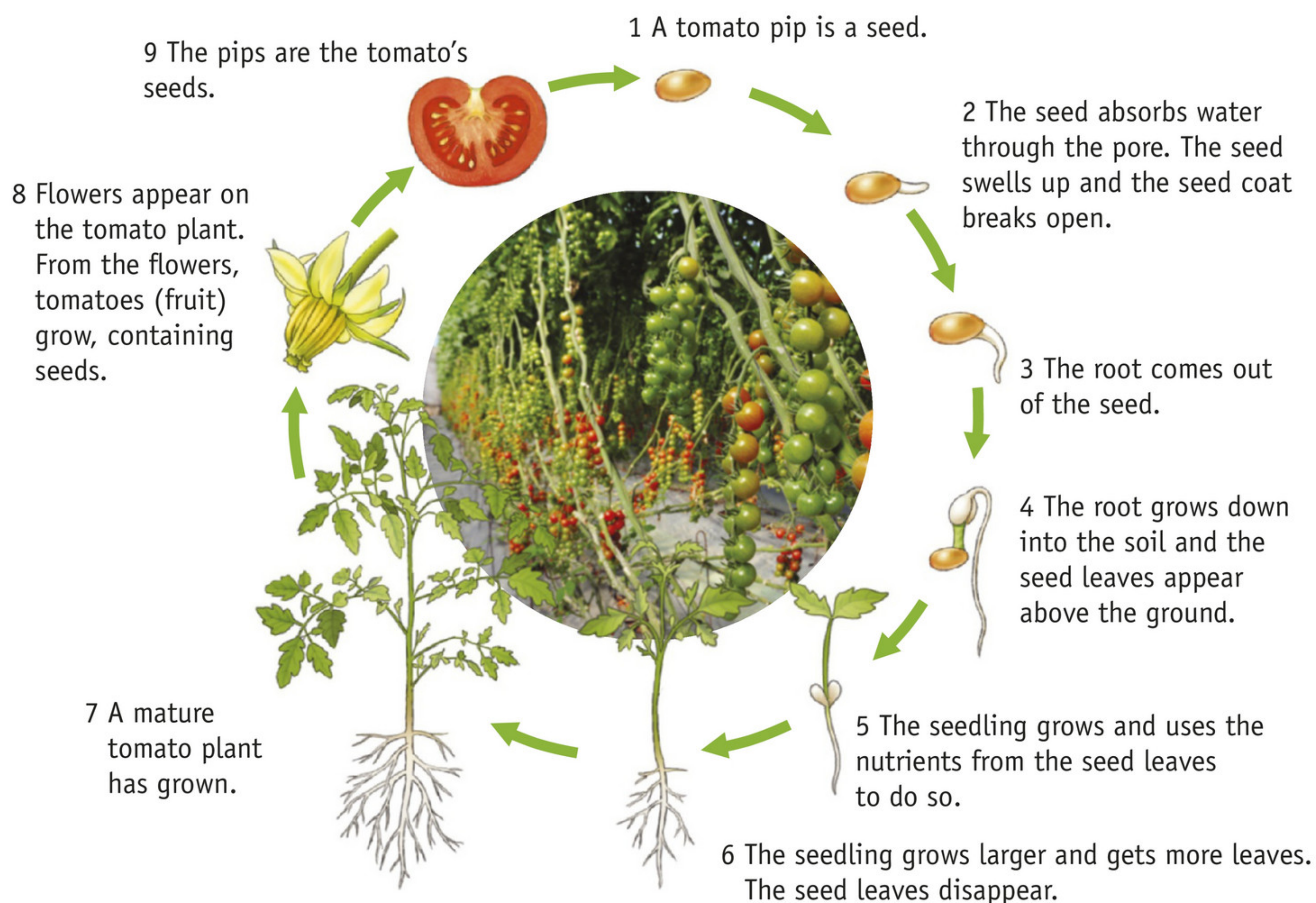
Jos van Mil is one of the six grower-owners at Greenco in Honselersdijk. Greenco is the inventor of the snack tomatoes that are sold under the brand name Tommies. "We're real entrepreneurs. Always looking for something new. Always doing new things is crucial for any businessman growing crops under glass. When we came across a small tomato in England in 2001 that had been produced by a Japanese plant breeding company, we immediately thought of doing something with it for kids. Obesity and convenience were getting a lot of attention, and the taste turned out to be just right for children. We thought up the name 'Tommies' and came up with the clown as the logo. And it just took off from there, so it became important that we could keep the product on the shelves all year round. That keeps you busy. Because there are six of us, we're able to share the tasks between us nicely!"



In Unit 1 What is biology? you looked at a bean. A bean is a seed. Tomatoes have seeds too: the pips. A tomato pip can grow into a new tomato plant. First, the seed grows into a seedling. You can see a tomato seed germinating in figure 3. Tomato growers generally buy the seedlings from a specialist company. The seedlings are looked after very carefully. The grower keeps a careful eye on the amount of water, nutrients and light that the young plants get.

The first leaves that appear above the ground are called the **seed leaves**. During germination, the seedling uses nutrients from the seed leaves. As the seedling grows further, the spare food supply in the seed leaves gets used up. The seed leaves then shrivel up and fall off. In the meantime, the plant is growing more leaves. Finally flowers will appear on the plant, from which the tomatoes grow. The development of a plant seed into a fruit is called the **lifecycle** of the plant. A cycle is a process that keeps repeating. The end of one cycle is the start of the next cycle.

▼ **Fig. 3** Lifecycle of a tomato plant.



DOING RESEARCH

To see how tomatoes can grow as well as possible, scientists carry out research. A lot of this research in the Netherlands is done at Wageningen University, but there are companies throughout the country as well that are researching how plants grow.

Research that starts by asking a question and that usually involves experiments is known as **scientific research**. Scientific research can be split up into a number of steps (or phases), as shown in figure 4. With the help of an example, you are going to see the steps that are involved.

▼ **Fig. 4** How to go about doing research.

1 THE PROBLEM DEFINITION: WHAT DO I WANT TO INVESTIGATE?

A piece of research or an experiment mostly begins when someone is wondering about a problem. For example: you have just bought a packet of seeds. You notice that the seeds in the packet are not germinating. So you ask yourself:

Why don't the seeds in a packet start germinating?

2 THE HYPOTHESIS: WHAT DO I THINK THE ANSWER MIGHT BE?

In this step, you think up an answer to the question.

You might suppose, for example:

The seeds in the packet don't germinate because they aren't getting any air.

3 THE MATERIALS: WHAT DO I NEED?

You will need various things to do your experiment: the materials or equipment. In this step, you make a list of everything you need. In our example:

- 2 identical packets of the same type of seed
- a needle

4 THE EXPERIMENT: WHAT AM I GOING TO DO?

In this step, you think up a way of proving that you are right. You want to prove that the seeds in the packet are not germinating because they are not getting any air. You think up an experiment to show this. To prove that the seeds are not germinating because they are not getting any air, you can prick holes in one pack of seeds. After a couple of days, that packet can be compared with one that did not have any holes pricked in it. This is how you could write it up:

I will take two packets of the same kind of seeds. I will prick holes in one packet so that air can get into it. I will not do this for the other one. After a few days, I will look to see if the seeds have germinated.

Then you carry out the experiment. Experiments in biology often take longer than a single lesson. So sometimes you will have to wait until the next lesson to see what has happened.

5 THE RESULTS: WHAT ARE MY OBSERVATIONS?

You look to see what has happened and you make a note of it. In our example:

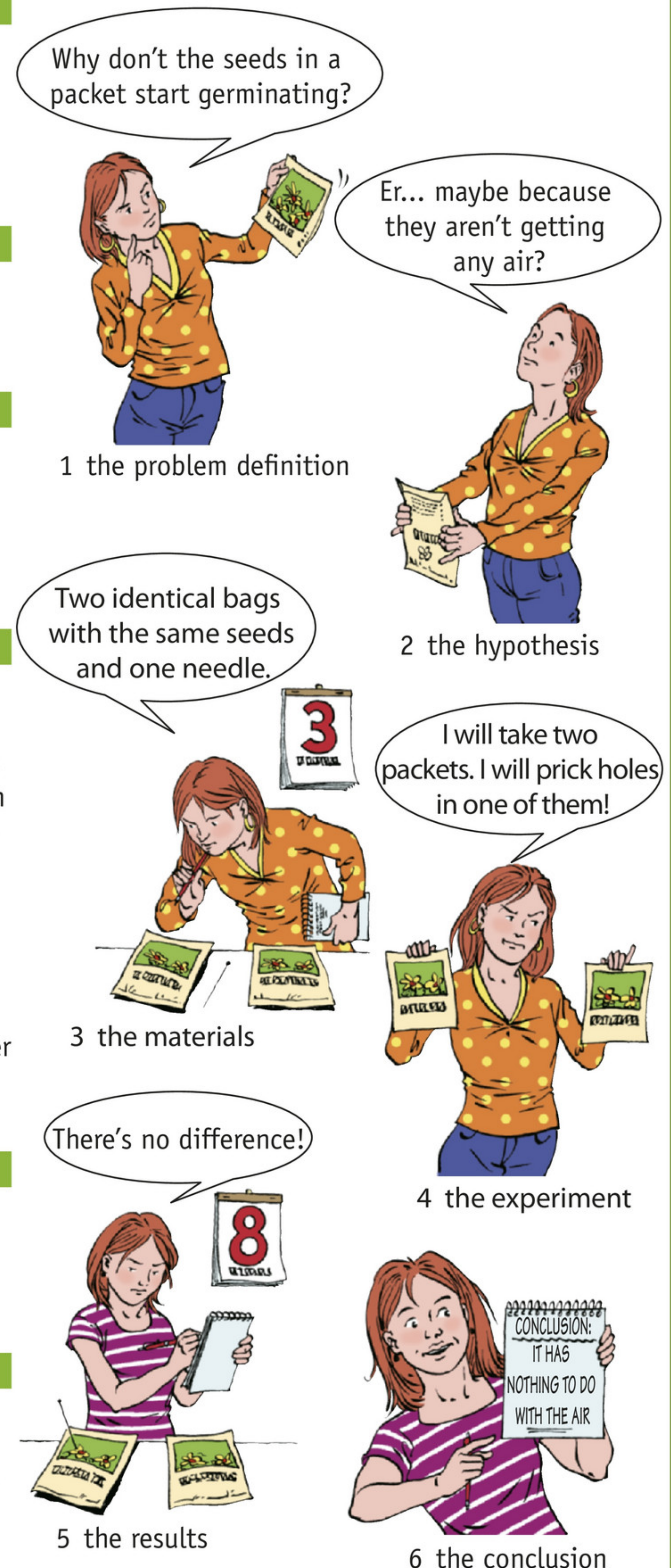
There is no difference between the seeds in the two packets. The seeds have not germinated in either of them.

6 THE CONCLUSION: WHAT CONCLUSION CAN BE DRAWN?

Finally you make a note of the conclusion that you can draw from the experiment. In our example, this is:

The seeds in the packet are not germinating, but this is not because they are not getting any air.

The hypothesis is therefore wrong.



WRITING A RESEARCH REPORT

If you do research or carry out an experiment, you have to write a *report*. A report should also always be structured the same way. You could write a report for our example using the sentences that are printed in italics. A report always starts with a title, your name and the names of the people you worked with. Then you make sections in the report for each of the research steps. The report lists the things that were needed for the experiment (see figure 5).

▼ **Fig. 5** A report.

Why don't the seeds in a packet start germinating?

Name: Pupil

Name: Second pupil

Problem definition

Why don't the seeds in a packet start germinating?

Hypothesis

The seeds in the packet don't germinate because they aren't getting any air.

Materials

- 2 identical packets of the same type of seed
- a needle

Experiment

I will take two packets of the same kind of seeds. I will prick holes in one packet so that air can get into it. I will not do this for the other one. After a few days, I will look to see if the seeds have germinated.

Result

There is no difference between the seeds in the two packets. The seeds have not germinated in either of them.

Conclusion

The seeds in the packet are not germinating, but this is not because they are not getting any air. The hypothesis is therefore wrong.



You do not yet have an answer to the question:

Why don't the seeds in a packet start germinating?

Apparently it has nothing to do with the air. You have probably heard that plants need water. Another hypothesis could be that the seeds are not germinating because they are not getting any water.

WB EXERCISES 1 AND 2, PAGE 36

THE EFFECT OF TEMPERATURE

Greenhouses are made of glass. Light can get through the glass and reach the plants. The glass also makes it warmer inside the greenhouse than outside. Large greenhouses are heated during the winter, so that the crops can be grown all year round.

In the winter, you see almost no plants flowering outside. It is usually too cold. Most plants only produce their seeds in the autumn. The seeds then fall on the ground, but do not germinate. You might wonder: *Why do seeds germinate in the summer but not in the winter?*

You probably already have a possible answer to that question, a hypothesis: *Seeds do not germinate in the winter because the temperature is too low.*

You are going to do an experiment to investigate the effect that temperature has on the germination of seeds. For this experiment, you will be using cress seeds. Cress seeds are easy to find and they usually germinate quickly. You must write a report of your experiment.

WB EXERCISES 3 AND 4, PAGE 39

2 Roots

▼ **Fig. 6** Seedlings with root hairs.

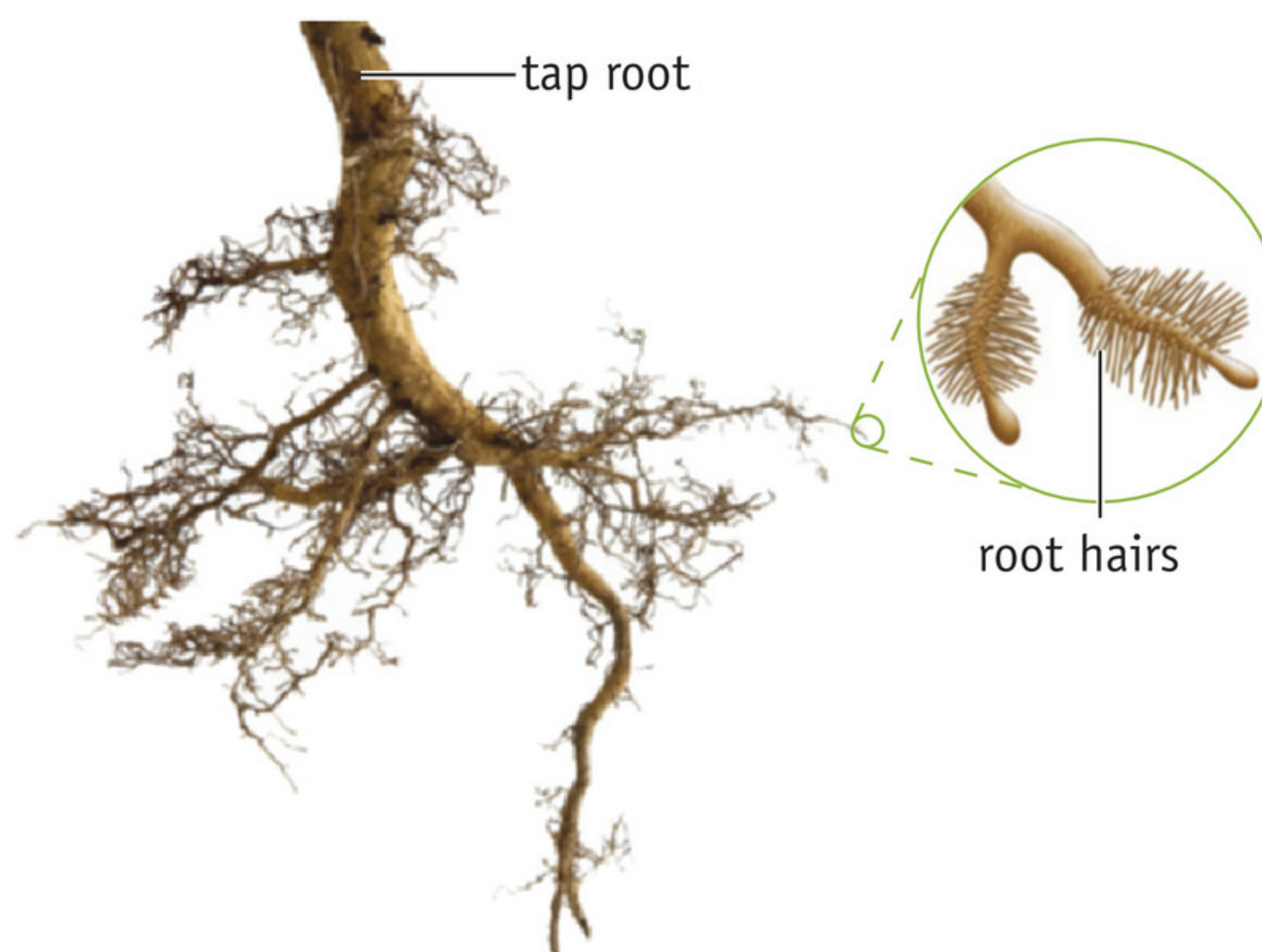


Seeds can be sown all year round in greenhouses. Tomatoes are often first sown in trays. The seedlings are close together then. As the plants get bigger, they need more space. They then have to be taken out of the trays and put into separate pots. This is known as **potting** them. When potting the seedlings, great care has to be taken to make sure that their roots are not damaged. The plant is therefore usually potted along with the soil around it. There are **root hairs** at the ends of the roots (see figure 6). Root hairs are very fine protrusions. You can only see them if you let the seedlings germinate on filter paper, for example.

ROOT SYSTEM

When a seedling grows into a plant, its root grows as well. The **tap root** gets longer and thicker and **lateral roots** appear (see figure 7). The root hairs are at the ends of the lateral roots. All the roots of a plant taken together are called its **root system**. The root systems of different plants often look very different. In bulbs, such as tulips and onions, you do not see a tap root and lateral roots (see figure 8). Trees can have very large root systems, with large lateral roots that seem to be snaking over the ground (see figure 9).

► **Fig. 7** Tap root with lateral roots.



▼ **Fig. 8** The root system of a tulip.



▼ **Fig. 9** The root system of a tree.



▼ **Fig. 10** Leaves and stems wilt if they do not get enough water.



THE FUNCTION OF ROOTS

If the root hairs of a plant get damaged, the plant will die. That is generally the reason why a plant dies after being re-potted. Among other things, plants need water and certain **nutrients** that are in the soil. These nutrients are **minerals** (salts) that are dissolved in the water in the soil. Plants can only absorb the water with its minerals from the soil through the root hairs. If you pull a plant up out of the ground, the leaves will wilt after a little while. This is because water evaporates from the leaves. The stems may weaken as well. But if you leave a plant with its roots in the soil, the leaves and stems will remain firm. A lack of water will therefore make a plant wilt (see figure 10). If there are not enough nutrients in the soil, plants grow poorly. In greenhouses, plants are grown all year round. This means that the soil in the greenhouses rapidly gets **exhausted**, meaning that the nutrients for the plants have been used up. Fertiliser is added to put the nutrients back into the soil. The **fertiliser** contains nutrients (minerals) for plants. Because the roots of most plants branch out a lot under the ground, the roots also make sure that the plant stays firmly anchored in the soil. The root hairs play a role here too. A single root hair is very fragile and easily broken, but a whole root system contains a vast number of root hairs. All those root hairs together hold the plant even more firmly in the ground.

In many plants, the parts that are above ground die off in the autumn. For instance, you hardly see any dandelions in the winter. They are still there, though. The parts that are under the ground (the roots) stay alive during the winter (see figure 11). These parts contain a lot of **food reserves**. In the spring, you soon see lots of dandelions appearing again. The parts above ground then grow quickly. The plant uses up the food reserves in the roots for this. When it is cold, plants absorb almost no water. Water still evaporates from the leaves, though. If plants with leaves stay in cold surroundings for a long time, the plants dry out.

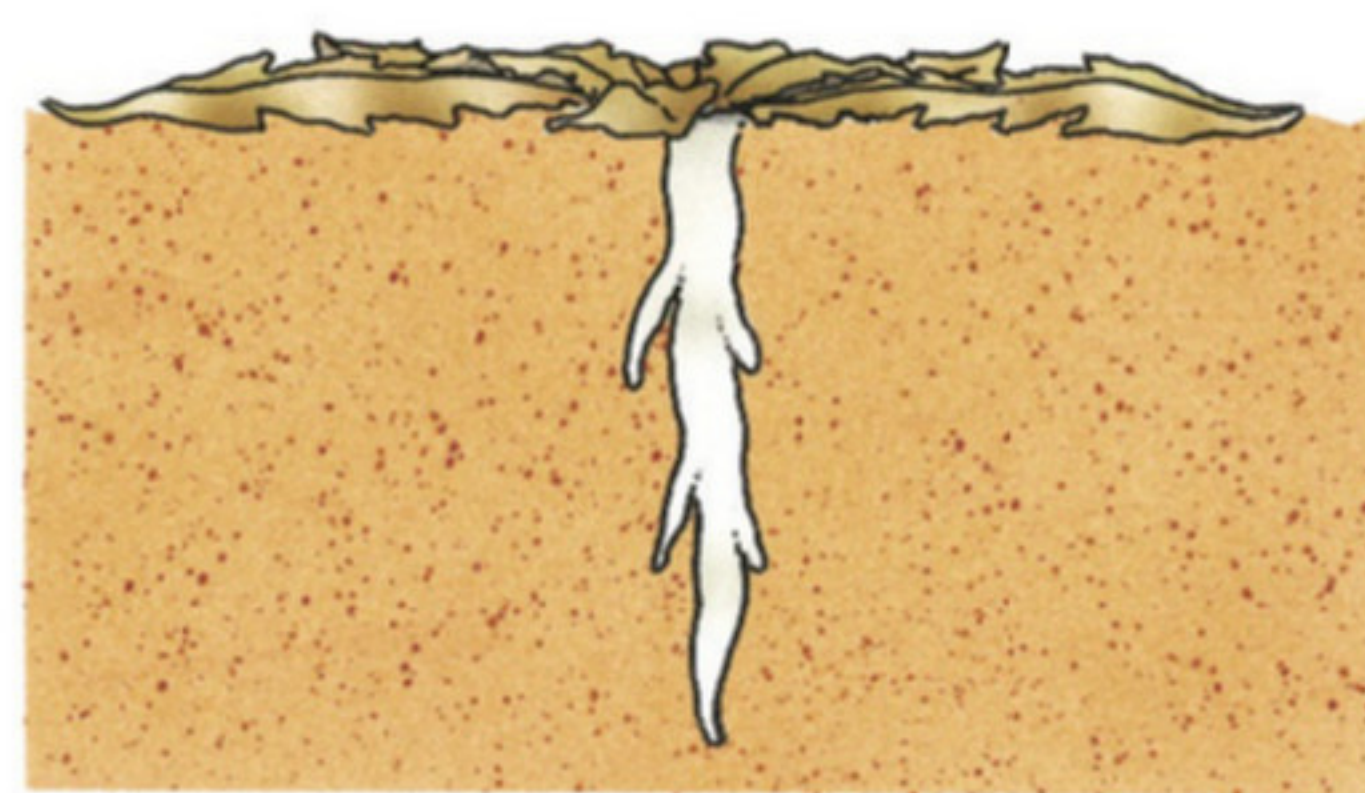
Dandelions stay alive through the winter because the parts that are above ground die off in the autumn. Most trees and shrubs lose their leaves in the autumn. This lets them stay alive through the winter as well.

Dandelions, trees and shrubs store their extra food in their roots. Many animals (such as rabbits, for example) mostly eat plant roots in the winter. They are then living from the food that the plants have stored. You also often eat the parts of plants in which a lot of spare food has been stored. You will learn more about that in Basics 5.

▼ **Fig. 11** A dandelion.



1 in the summer



2 in the winter

WB EXERCISES 5 AND 6, PAGE 40

3 Stems

▼ **Fig. 12** Small tomato plants.



▼ **Fig. 13** Tying up tomato plants.



► **Fig. 14** A piece of stem (a twig) of a horse chestnut tree.

The scientific name for the tomato plant is *Solanum lycopersicum*. The plant was brought to Europe from South America by the Spanish about 500 years ago. It was a small, shrub-like plant related to the potato and the aubergine (see figure 12). Over the course of time, cultivators have developed the current tomato varieties from this plant. This cultivation has created plants with long stems that get bent over by the weight of the tomatoes. To make sure that the tomato plants stay upright, the growers tie them in place (see figure 13).

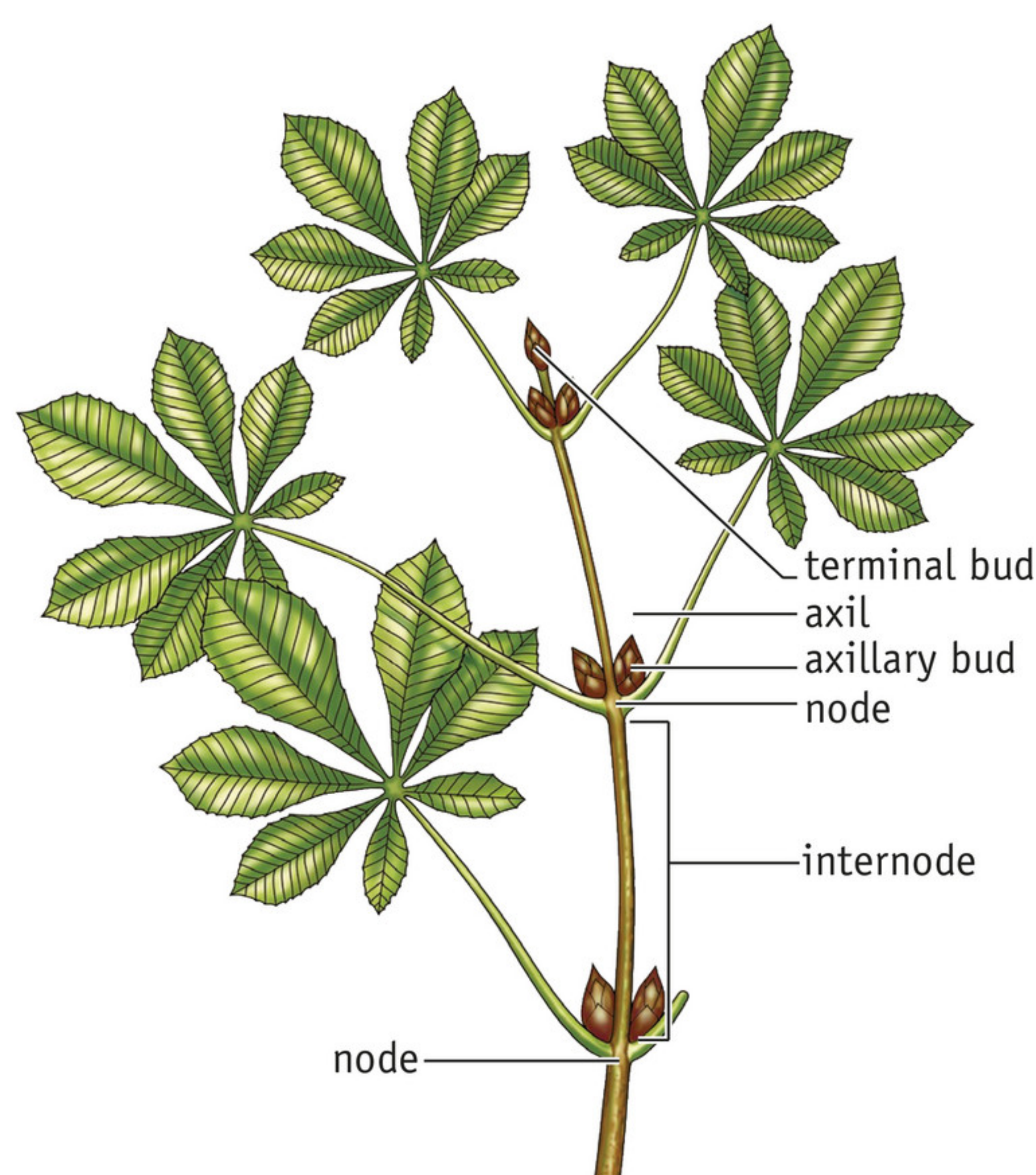
THE STRUCTURE OF A STEM

A stem (or twig) has various different parts (see figure 14). The place where a leaf is attached to the stem is called a **node**. The stem is usually a bit thicker there. The piece of stem between two nodes is called an **internode**. A stem is made up of alternating nodes and internodes.

The upper angle between the stem and the leaf is called the **axil**. In the axil, you can see an **axillary bud**. Next year, a twig with its own leaves will branch out from the axillary bud. At the end of the stem, there is a **terminal bud**. A new section of this stem with leaves on will grow from the terminal bud next year. Flowers may also be attached to the stem.

Trees and shrubs have very robust stems: the trunks and branches. These are stems that contain a lot of wood. We therefore call trees and shrubs **woody plants**. The stems of other plants contain virtually no wood. We call these **herbaceous plants**. The stems of herbaceous plants stay firm as long as the roots are able to absorb enough water (see figure 10).

WB EXERCISES 7 AND 8, PAGE 43



ANNUAL RINGS

Plants grow longer at their ends, for example from the terminal buds. The roots also grow from the tips of the roots. New root hairs continue to appear here too, as the old ones die. So the root hairs are always found at the ends of the roots.

In a tree trunk there is a layer just underneath the bark which creates a layer of wood on the inside. During the spring, the tree grows fast and the layer is light-coloured. During the summer, the tree grows less quickly and the layer is darker in colour. The tree does not grow during autumn and winter. This means that a layer of wood is created each year that is first pale and then darker. You can see this clearly on a cross-section of a tree trunk. The wood that a tree adds in a single year is called an **annual ring** and it consists of a lighter layer and then a darker layer (see figure 15). The oldest wood is in the middle of the trunk. The annual ring that was produced most recently is on the outside.

If a tree has been sawn through just above ground level, you can find out how old the tree was. You do that by counting the annual rings. Sometimes the oldest rings are compressed together a lot. You are usually unable to distinguish properly between the annual rings then.

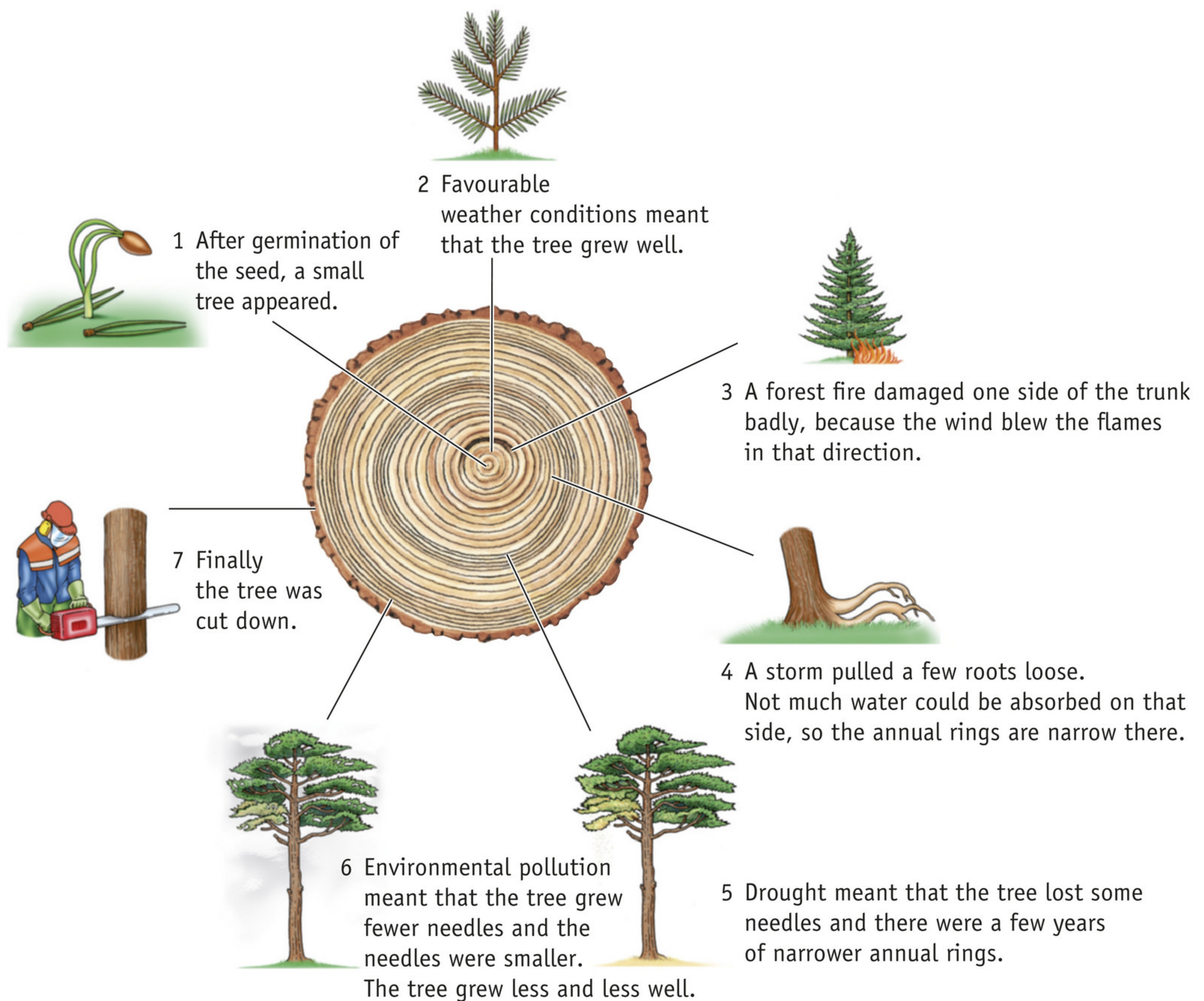
► **Fig. 15** Annual rings.



By comparing the different annual rings, you can find out more about the environmental conditions that the tree was growing in. If the conditions were favourable, the annual ring will be wide. If the environmental conditions were unfavourable, the annual ring will be narrow. Unfavourable conditions could be caused by drought, a forest fire, a plague of insects, and so forth. Figure 16 shows how the life story of a Scots pine can be seen in a cross section of the trunk.

WB EXERCISE 9, PAGE 44

▼ Fig. 16 The life history of a Scots pine.



THE FUNCTIONS OF STEMS

The tomatoes on a tomato plant need a lot of water and nutrients as they grow. The roots take up water and some of the nutrients that are needed from the ground. Other nutrients are produced in the leaves of the tomato plant. You will learn more about this in Basics 4.

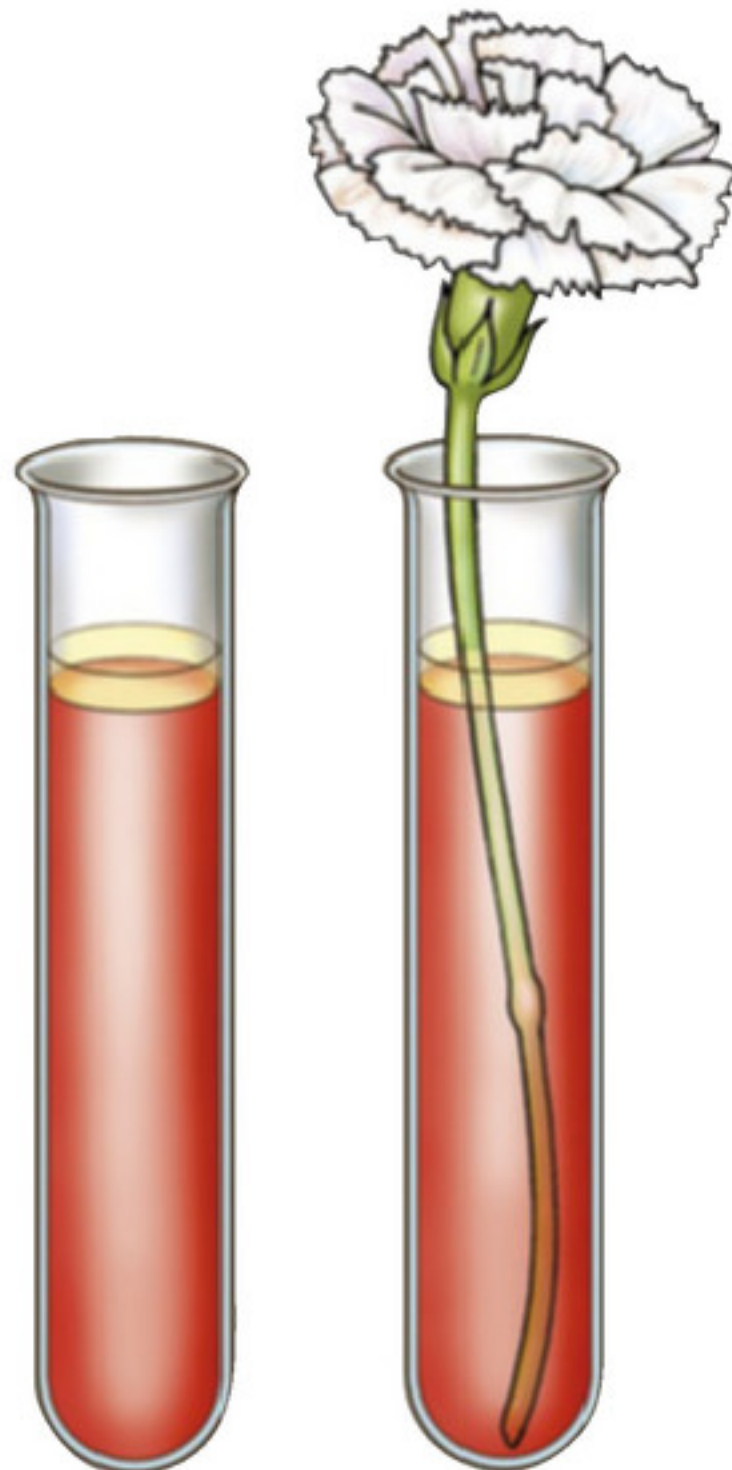
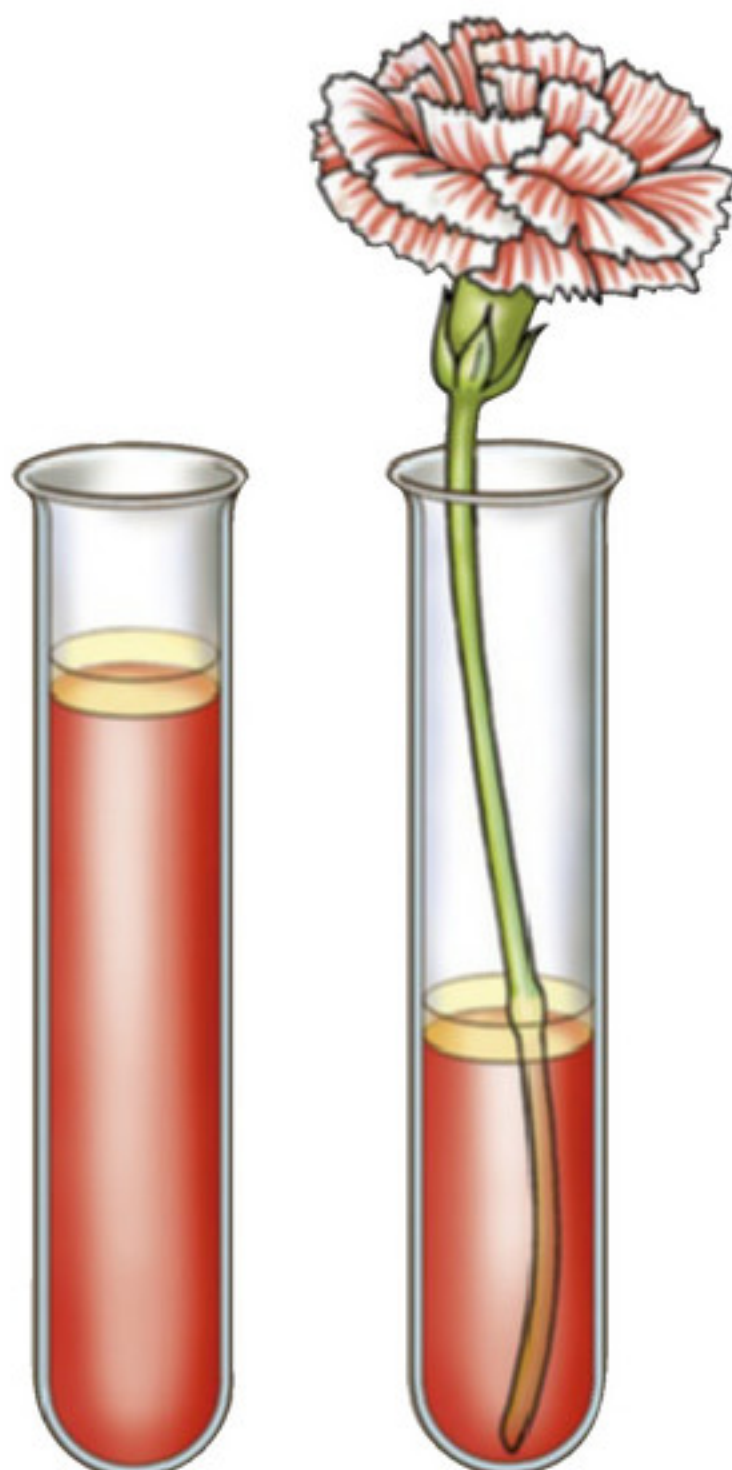
The stem of a plant transports the water and nutrients. You can demonstrate this function of the stem if you stand stems with white flowers in water that has a red dye dissolved in it. Figure 17 shows you the result after a few days.

Long thin tubes run through a stem, known as its **vessels**. In some plants, these vessels are grouped closely together in **vascular bundles** (see figure 18). These vascular bundles start in the roots and go right along the stem to the fruits, flowers and leaves. Vessels **transport** substances around in the plant.

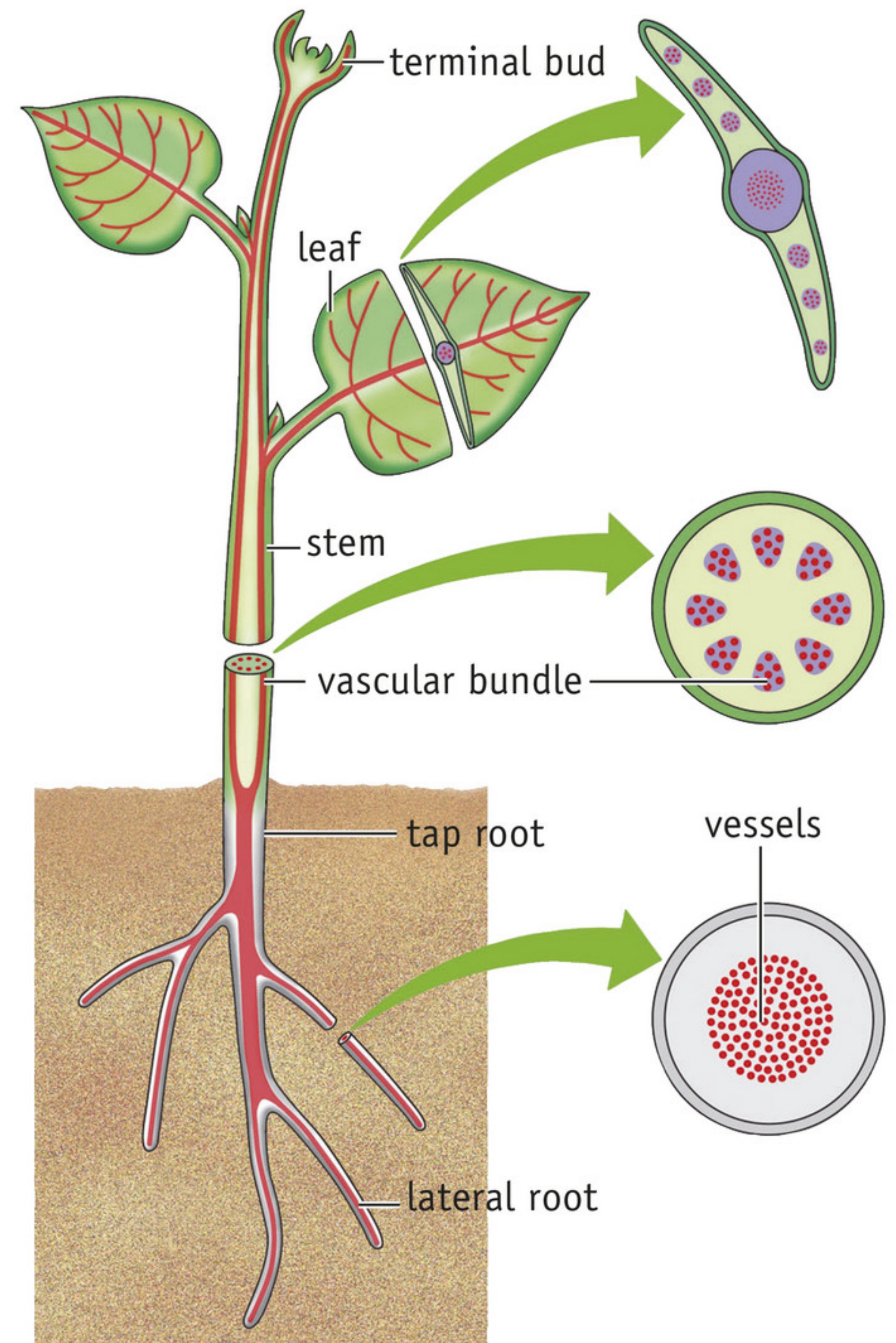
In many plants, the stem provides the stiffness that lets the plant stay upright. Plants with sturdy stems can grow bigger. Climbing plants have stems that are able to climb up along something else.

WB EXERCISES 10 AND 11, PAGE 46

▼ **Fig. 17** Investigating the function of the stem.

INVESTIGATION	THE FUNCTION OF THE STEM
Problem definition	
Experiment	Water with a dissolved dye is placed in two test tubes. There is a layer of oil on top of the coloured water, so that the water cannot evaporate. A white carnation is placed with its stalk in the dyed water in one of the test tubes. The other test tube is a control, to check that the water does not evaporate from the test tube.
	
Results	A few days later. 
Conclusion	The stem transports the water and any substances dissolved in it.

▼ **Fig. 18** A plant with vascular bundles.



4 Leaves

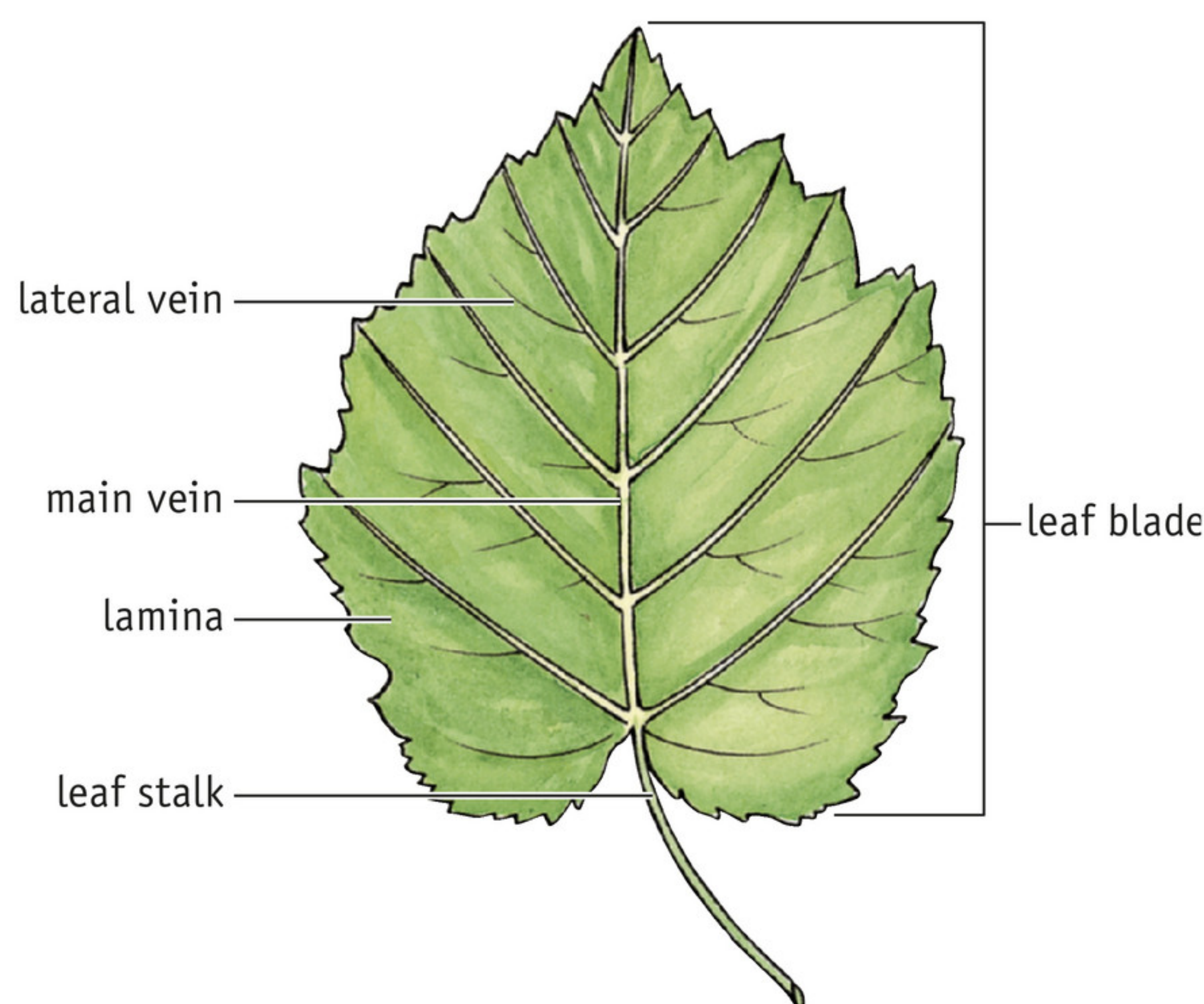
A leaf consists of a leaf stalk and a leaf blade. The **leaf stalk** is where the leaf is attached to the stem. The flat part of the leaf is called the **leaf blade** (see figure 19).

The vascular bundles in the stem go via the leaf stalk right into the blade of the leaf (see figure 18). The **veins** of the leaf can be seen in the blade. The **main vein** usually runs down the centre of the leaf. The branches coming off the main vein are called **lateral veins**. These branch off into smaller and smaller veins. The veins consist of vascular bundles. They stiffen up the leaf's shape and transport its water and nutrients. All the material that is between the veins is called the **lamina**.

A leaf that no longer has any lamina is called a **leaf skeleton** (see figure 20). A leaf skeleton consists only of its veins. You can easily find leaf skeletons in the autumn, for example in amongst the leaves that have fallen from the trees.

WB EXERCISE 12, PAGE 48

▼ Fig. 19 A leaf.



▼ Fig. 20 A leaf skeleton.



THE FUNCTION OF LEAVES

All organisms need substances to keep them alive and to let them grow. For humans and animals, these substances come from the air that they breathe and the food that they eat.

Humans and animals feed on other organisms or parts of other organisms. Humans' food may come from plants or from animals. The food provides the substances that your body is made of.

Plants do *not* feed on other organisms. The substances that a plant consists of are made by the plant itself. To do this, the plant uses substances from the soil and the air. The leaves in particular have an important role in producing the substances that the plant is made of.

▼ **Fig. 21** In shops, glucose is often called dextrose.

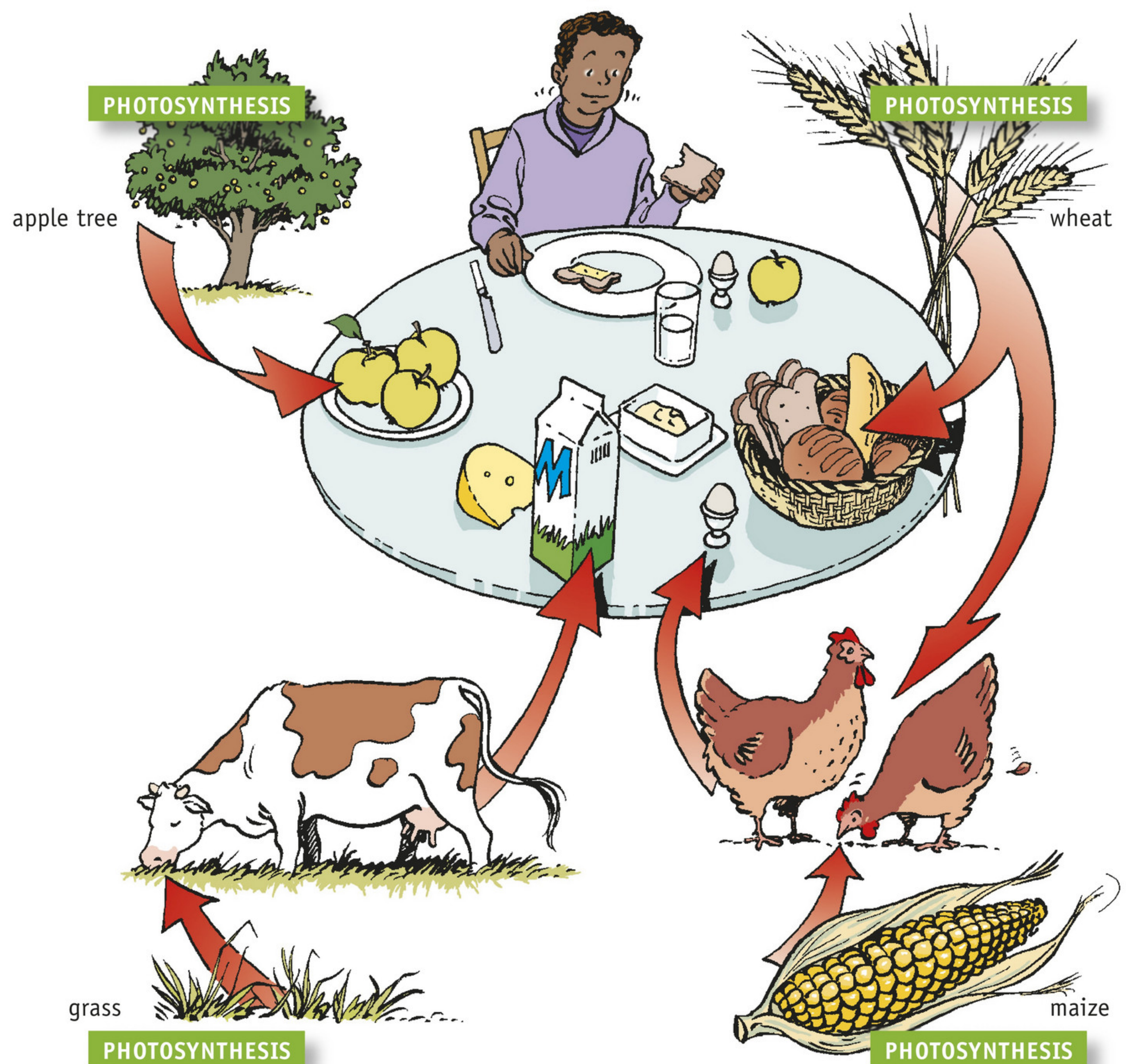


PHOTOSYNTHESIS

A process called **photosynthesis** takes place inside plants. Photosynthesis occurs mostly in the leaves. In photosynthesis, a substance called **glucose** is made. Glucose is an important substance for plants. Glucose is a kind of sugar, also known as dextrose or grape sugar (see figure 21). A plant uses glucose to make all sorts of other substances, including the substances that the plant is made of. This also requires other substances that the plant extracts from the soil.

Photosynthesis is also important for people and animals. Almost everything that people eat ultimately comes from plants. A piece of meat may come from a cow, for example, but that cow ate grass. An egg comes from a chicken, but that chicken ate maize (see figure 22).

▼ **Fig. 22** The importance of photosynthesis.



A plant needs certain substances to make glucose. One of those substances is *water*. You have learned that the roots of a plant draw water up from the soil, and that the vessels transport the water from the roots to the leaves. The water then enters into the lamina via the veins in the leaves.

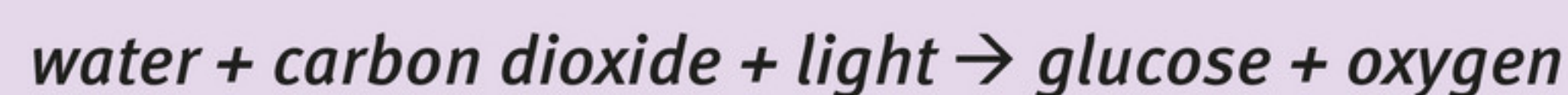
The other substance that is needed for photosynthesis is **carbon dioxide**, which comes from the air. The leaves absorb carbon dioxide from the air through small openings. Carbon dioxide is a gas. You cannot see it. You have come across it before though: the fizzy bubbles in lemonade or cola are carbon dioxide.

Photosynthesis also needs **light** (*photos* is Greek for 'light'). Plants that are left in the dark the whole time will die after a few weeks because they are unable to photosynthesise.

Photosynthesis does not only produce glucose: it also releases **oxygen**. Oxygen is a gas. It is one of the components of air, just as carbon dioxide is. The oxygen is released by the plant into the air through small openings in the leaves. Water plants absorb carbon dioxide from the water and release oxygen into the water. When a water plant is releasing a lot of oxygen into the water, you can sometimes see this as bubbles rising up from the plant.

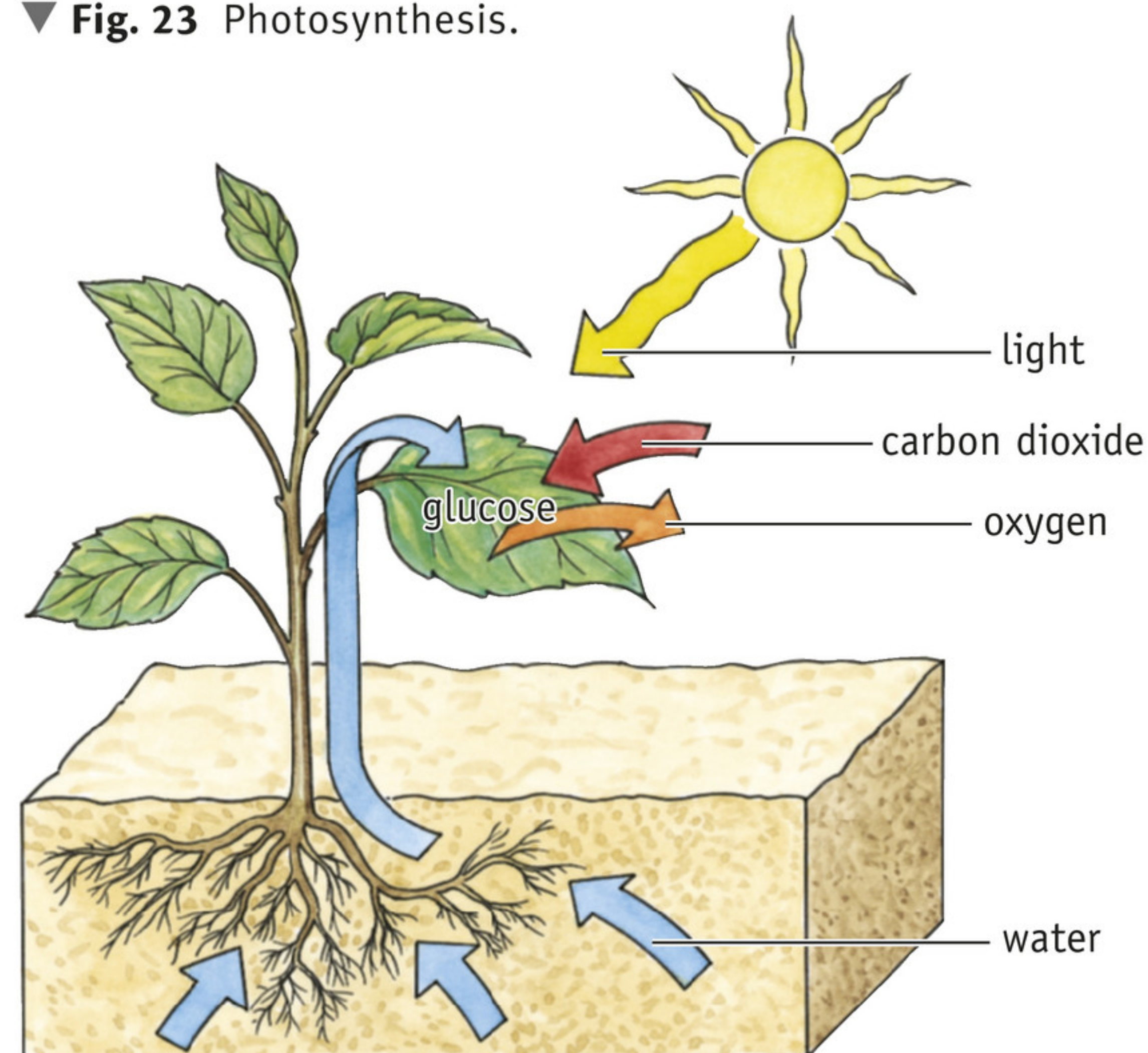
Figure 23 is a diagram showing what photosynthesis does. Water, carbon dioxide and light are needed for photosynthesis. During photosynthesis, glucose and oxygen are produced.

You can summarise photosynthesis as follows:



To the left of the arrow is everything that is needed for photosynthesis. To the right of the arrow is everything that is produced by photosynthesis.

▼ **Fig. 23** Photosynthesis.



Photosynthesis is how new food can keep being produced on Earth. It also keeps renewing the oxygen. People and animals use oxygen. Because photosynthesis generates oxygen, there is always enough oxygen in the air. Without photosynthesis, the oxygen in the air would slowly all get used up. Photosynthesis does not take place only in the leaves: in fact, it occurs in all **green parts** of a plant. So plants with green stems are also photosynthesising in the stems; but mostly in the leaves, though.

LIGHT AND PHOTOSYNTHESIS

Many plants do not grow in the winter because it is too cold. While growing plants in a greenhouse lets you keep them warm in the winter, just keeping them warm is not enough. There is much less light in the winter than in the summer as well.

In the winter, when it gets dark earlier, you can see the lighting in the greenhouses very easily. When growing tomatoes, the cultivator makes sure that the tomatoes always get enough light. The more light a plant gets, the longer photosynthesis can carry on for in the plant and the better it will grow. But to be able to grow well, plants also need a period of darkness. The period that a plant gets light for is called the day length, and it will be different for each crop. For tomatoes, the best growth is obtained when the day length is approximately fifteen hours.

Lighting a greenhouse uses a lot of energy. The amount of energy needed can be reduced by using energy-saving bulbs and the right colour of light (see figure 24). Leaves are green because the plants use red and blue light, but not green light. The green light is reflected and so we see leaves as being green in colour.

WB EXERCISES 13 TO 15, PAGE 49

▼ Fig. 24

LED lighting in the greenhouse

To encourage plant growth, most greenhouses are lit with growing lights. In the winter in particular, you can see the orange light from the greenhouses from a long way off. Growing lights use a lot of energy. A large proportion of the energy is turned into heat and only a small fraction becomes light. They also get very hot. In 2008, growers started using LED lighting. LED bulbs use much less energy and get much less hot.

The colour of the lamps is also important for growth. For plants to grow well, red light and blue light are particularly important. Using LED lights lets you adjust the colour of the light very well and, because they give off a lot less heat, you can also hang them closer above the plants, which means that less light is lost. It is expected that using LED lights will be able to halve energy costs.



5 Edible roots, stems and leaves

Plants that humans use parts of as food are known as **food crops**. So a tomato plant is a food crop. We use the fruits of the tomato plant. There are other plants, such as rice and corn, that we use the seeds of. You will learn more about fruits and seeds in Unit 7.

Food crops are plants that are cultivated by people. Many plants have been cultivated for thousands of years, with the edible parts mostly having become much bigger and tastier than in the original plant (see figure 25). Nowadays, people in the Netherlands are more and more interested in the quality and the taste rather than the size. The yield per plant is still important, though, and whether the plant is healthy and whether it gets damaged by insects.

▼ Fig. 25

The carrot

The carrot (*Daucus carota*) as we now know it probably comes from Iran or Afghanistan and was probably dark in colour. This plant is thought to have been grown in the past for the aroma of the leaves and the seeds. Dill, a close relative of the carrot, is still used for its aroma and taste.

The original carrots that came to Europe were a variety of colours, such as yellow, red and white. In the seventeenth century, Dutch cultivators were able to grow carrots that were orange. Growing this orange variety led to the various types of carrots that you can now buy in the shops.



1 in the past



2 now

In Basics 2, you learned that the **roots** of many plants contain food stores. Many animals (such as rabbits, for example) mostly eat plant roots in the winter. We often eat plant roots too, for example carrots, parsnips, radishes and beetroot. These cultivated plants have thicker roots than the wild variants.

There are some food crops that we use the **stems** of. A potato is a thickening in the stem of a potato plant, containing a large food reserve. We also eat the stems of asparagus.

For most green vegetables, you eat the **leaves** of the plants. Examples of these vegetables are lettuce, spinach, endives, chicory, cabbage and leek (see figure 26).

WB EXERCISES 16 TO 18, PAGE 53

▼ Fig. 26 Edible plants.



1 you eat the roots of beetroot



2 you eat the stems of asparagus



3 you eat the leaves of chicory

6 Designing an experiment

In Basics 1, you learned that we do experiments in biology in order to investigate something. When you are designing an experiment of your own to investigate something, you make a **work plan**. A work plan describes the experiment you want to carry out in order to investigate the question you are asking, what you need for it, and how you are going to process the results.

▼ Fig. 27 Making a work plan.

WHAT AM I GOING TO DO?

A lot of salt is spread in the winter. I'd like to know if salt makes plants grow worse. So I'm going to investigate the effect of salt on how well plants grow.

1 What do you want to investigate?



With beans. They are easy to get hold of all year round and they germinate quickly.

2 What species of organism will you do the experiment with? And why are you using this species?



I will take five beans for each experiment.

3 How many organisms will you need for reliable results?



I will take two Petri dishes. I will put cotton wool, a little water with salt (one cup of water and two teaspoons of salt) and five beans into the Petri dish for the test group. I will do the same for the control group, but with just water and no salt.

4 What conditions are you going to expose the test group and the control group to?



The temperature and the amounts of moisture and light have to be the same. The beans must also be about the same size and come from the same packet.

5 How can you make sure that other factors do not have an effect?



WHAT DO I NEED?

I need:

- 2 Petri dishes
- cotton wool
- water
- salt
- 10 beans

6 What do you need for doing the experiment?



WHAT ARE MY OBSERVATIONS?

I will use a ruler to measure how tall the plants are.

7 How will you determine the result of the experiment?



Plant heights	Water	Water and salt
Day 3		
Day 5		
Day 12		

8 How will you present the results of the experiment? For example in a drawing, in a table, in a graph or as a bar chart?

You can see an example of a work plan in figure 27. The work plan for this experiment consists of eight questions.

To make sure the results are reliable, questions 3, 4 and 5 from the work plan in figure 27 are particularly important.

ENOUGH ORGANISMS

If you carry out the experiment with just a single plant, the result may depend too much on random chance. The plant might be unhealthy, for instance, without you having noticed it. To get reliable data, you must therefore carry out any single experiment with several plants. This is not always possible with experiments at school. You can sometimes use the results of others in your class as well.

TEST GROUP AND CONTROL GROUP

You often work with a **test group** and a **control group**. The test group is exposed to whatever **factor** you want to investigate the effect of, but the control group is not. In the example from figure 27, the beans from the test group are given water **with** salt and the beans from the control group are given water **without** salt.

ONLY ONE FACTOR IS DIFFERENT

All the other conditions must be the same. If you store the test group at a different temperature than the control group, for example, then you will not get reliable results. Any difference between the two groups could then also have been caused by the difference in temperature.

AN INVESTIGATION OF THE STRENGTH OF STEMS

The stems have to be sturdy to be able to bear the weight of the leaves and flowers. In Basics 2, you learned that the stem of a plant wilts if the roots are no longer able to draw up water. It would seem that the stem of a plant needs water if it is to be firm. To investigate whether this hypothesis holds for herbaceous plants, you are going to design an experiment (see figure 28). You will be doing this with the help of a work plan.

WB EXERCISES 19 AND 20, PAGE 54

▼ **Fig. 28** A white deadnettle is a herbaceous plant.

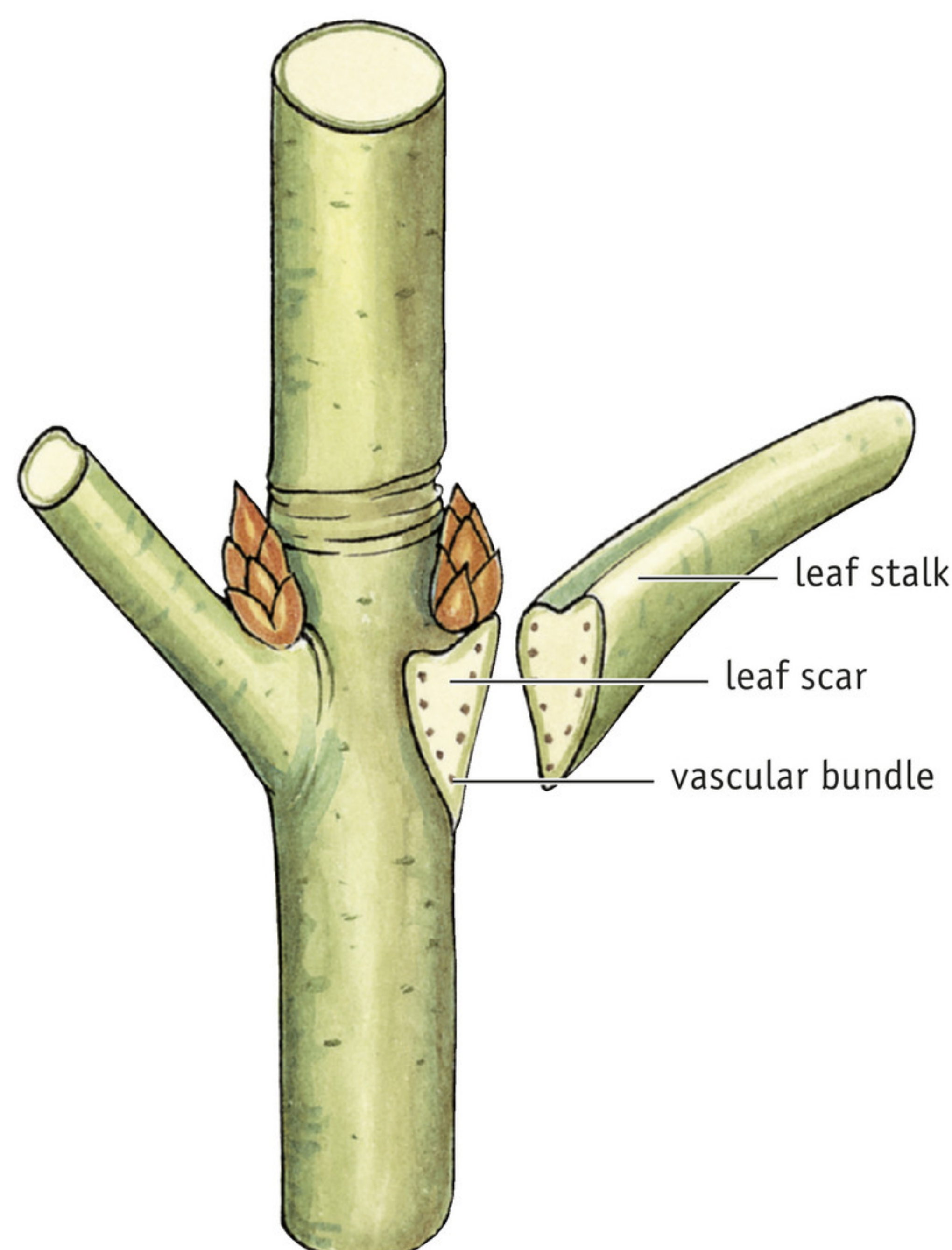


7 Twigs

Most trees and shrubs lose their leaves in the autumn. In the majority of trees and shrubs, a soft layer appears between the leaf stalk and the stem as autumn approaches: the **abscission layer**. At that point, the leaf is still attached to the stem only by its vascular bundles.

The wind or the weight of the leaf then pulls the leaf stalk away from the stem. A ‘wound’ is left on the stem, made by a layer of **cork** that protects the tree or shrub against moisture loss and diseases. We refer to this layer of cork as a **leaf scar**. You can see the ends of the vessels in the leaf scar (see figure 29).

▼ **Fig. 29** A leaf scar.



In the winter, you can see various leaf scars on the twigs of a chestnut tree (see figure 30). You can also see axillary buds and a terminal bud. You learned what axillary buds and terminal buds are in Basics 3. New stems and leaves will grow from these buds next year. Some terminal buds produce flowers. There are **bud scales** around a bud to protect it. The bud scales of a wild chestnut tree are very sticky.

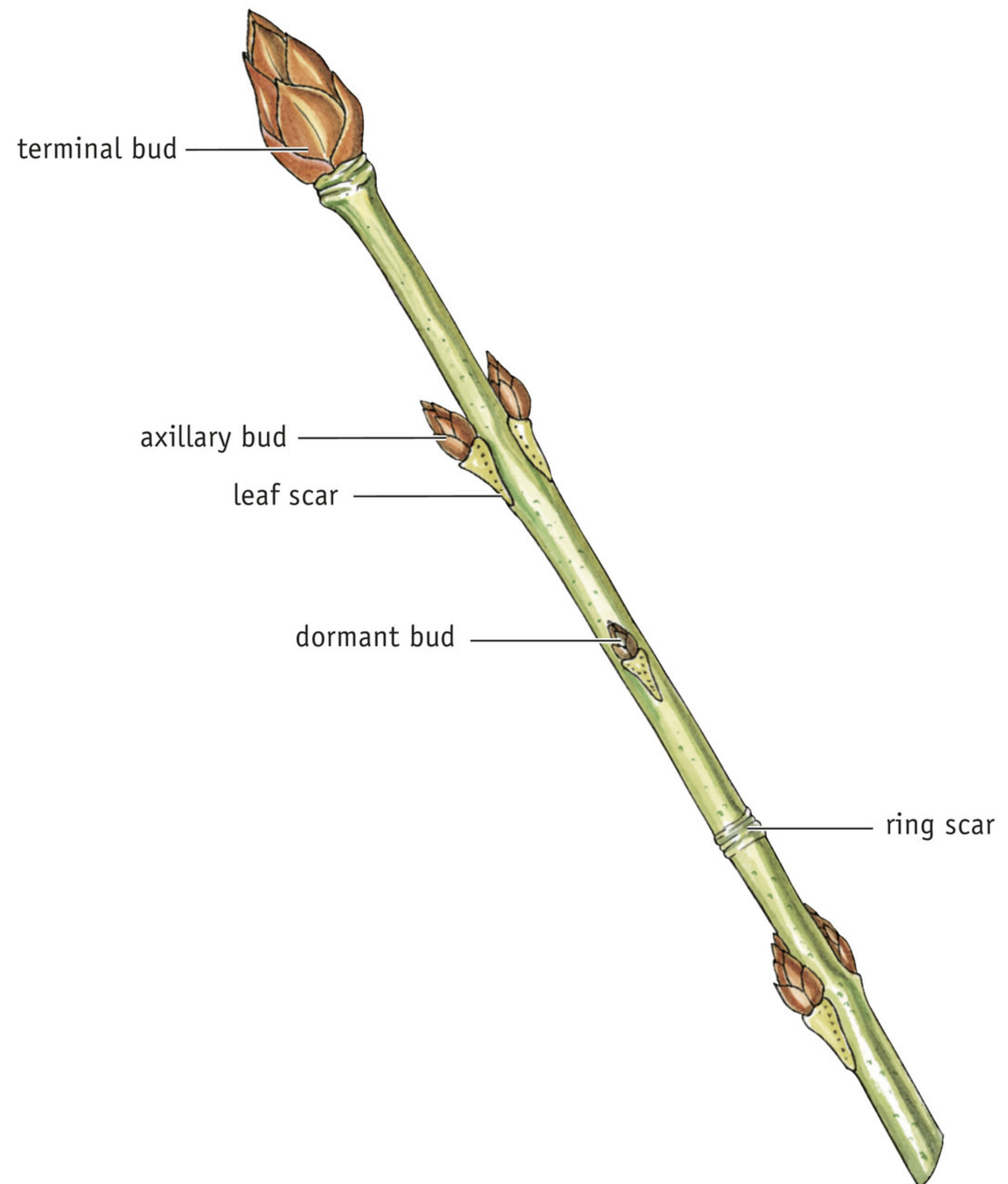
A twig also has buds that do not grow the next year. These are called **dormant buds**. But if the other buds are damaged or cut off, then the dormant buds will grow.

When a terminal bud starts growing in the spring, the bud scales fall off. This leaves a **ring scar**. The ring scar closest to the terminal bud shows where the last terminal bud was during the previous winter. The piece of the twig between the terminal bud and the first ring scar grew in a single year. The

piece of the twig between the first ring scar and the next ring scar is what grew in the year before. The ring scars show you how much the twig grew each year.

WB EXERCISES 21 AND 22, PAGE 56

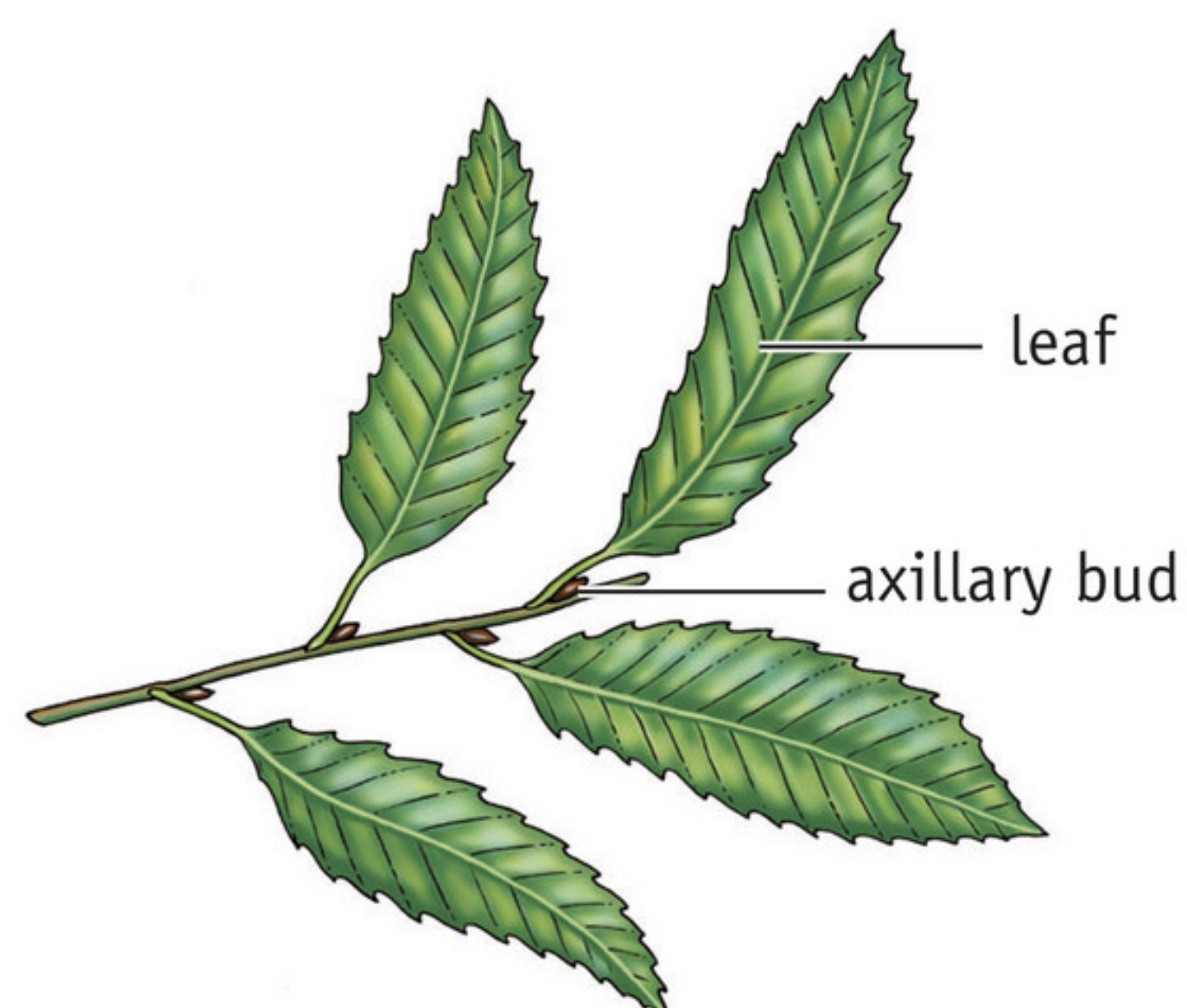
▼ **Fig. 30** A twig of a chestnut tree in the winter.



8 Leaf morphology

The leaves of different plants often look very different. In this section, you will learn about a number of different features of leaves.

▼ **Fig. 31** Simple leaves (sweet chestnut).

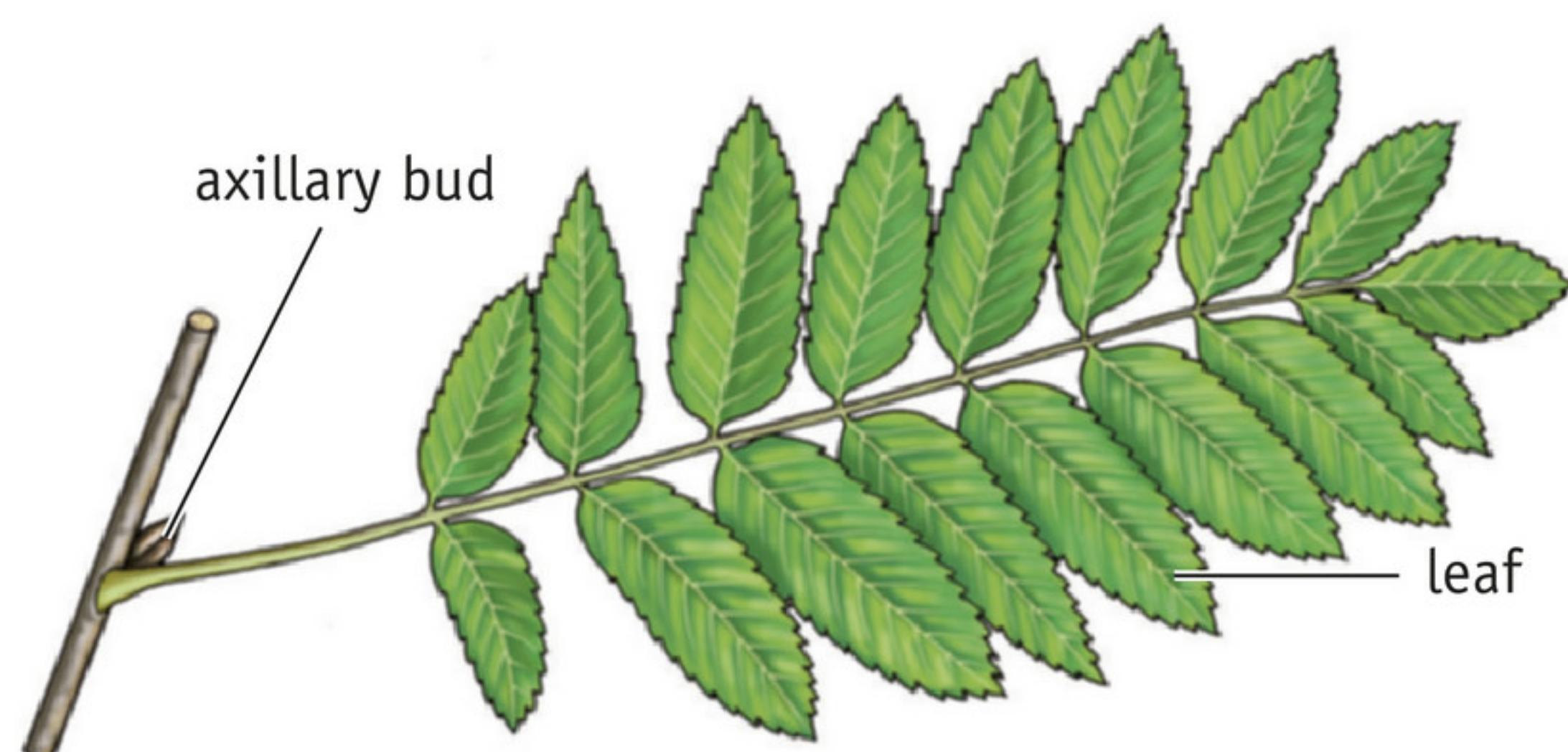


LEAF SHAPE

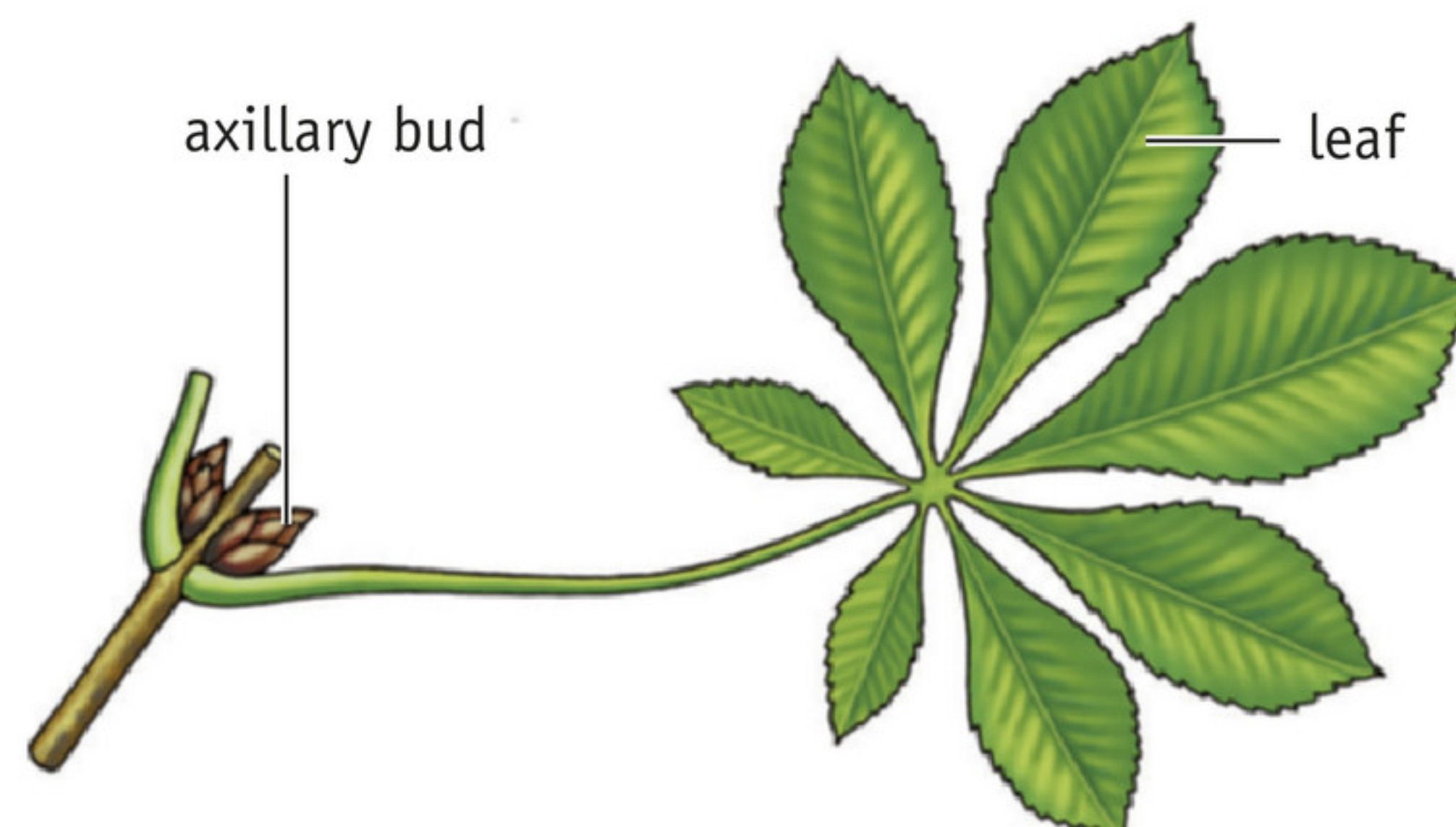
Most plants have leaves that consist of a single leaf blade. We call these **simple leaves**. There is an axillary bud at the point where the leaf stalk is attached to the stem. Plants that have simple leaves have as many axillary buds as there are leaf blades (see figure 31).

There are also plants in which the blade consists of several parts. We call these **compound leaves**. The blade then consists of several **leaflets**, which are connected to the stem by a single leaf stalk. There is therefore just a single axillary bud for all the leaflets together (see figure 32).

▼ **Fig. 32** Compound leaves.



1 pinnately compound leaf (rowan)



2 palmately compound leaf (chestnut tree)

The axillary buds show you whether the plant has simple leaves or compound leaves. Each simple leaf has a single axillary bud. If several leaflets together have a single axillary bud, then they make up a single compound leaf.

Figure 32.1 shows you a **pinnately compound leaf**. The structure of this kind of leaf looks like a bird's feather. Figure 32.2 shows you a **palmately compound leaf**. The leaflets are then arranged more like the fingers of a hand. Palmately compound leaves generally have three, five or seven leaflets.

WB EXERCISE 23, PAGE 58

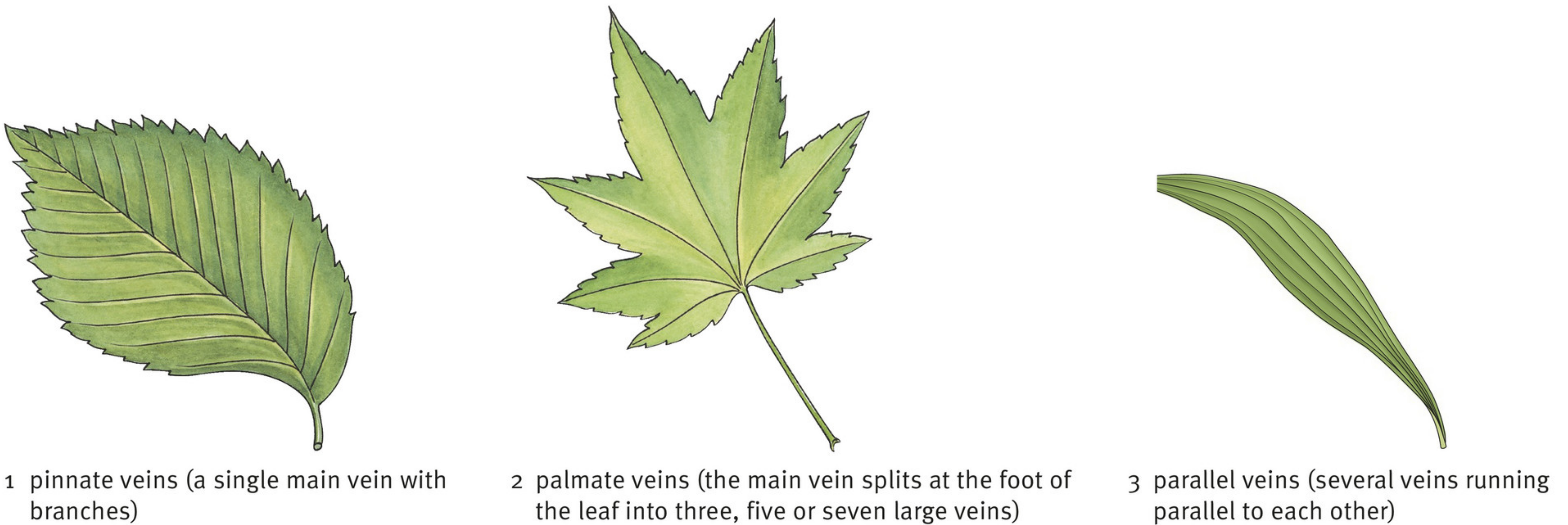
VENATION AND LEAF MARGIN

Other features of a leaf are the venation and the leaf margin. The way the veins run through a leaf is known as the **venation**. We classify leaves into ones with pinnate, palmate and parallel veins (see figure 33).

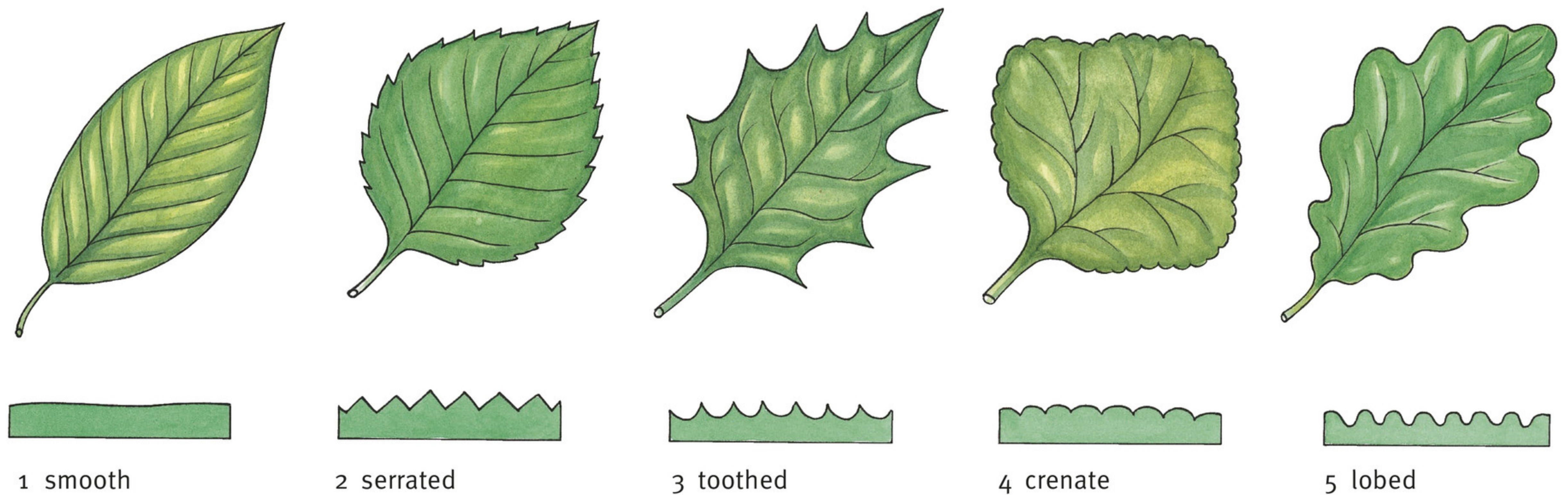
The leaf margin may be smooth, meaning that its edges are a smooth line. Many leaves have margins that are not smooth, but instead have parts of the edges that are indented or protruding. Figure 34 shows you five different types of leaf margins.

WB EXERCISES 24 TO 26, PAGE 58

▼ **Fig. 33** Venation.



▼ **Fig. 34** Leaf margins.



Summary

OBJECTIVE 1

You must be able to describe the lifecycle of a plant.

- Germination.
 - A seed absorbs water and the seed coat then breaks open.
 - The root grows and comes out of the seed, after which the seed leaves come up out of the soil.
 - The seed leaves contain nutrients and produce the first pair of leaves.
- The seedling is the small plant that is produced on germination.
 - The substances from the seed leaves are used up and the seed leaves then shrivel and fall off.
- Mature plant.
 - Flowers grow on the plant.
 - Fruits containing seeds are produced from the flowers.

OBJECTIVE 2

You must be able to describe the six steps for carrying out research and you must be able to recognise them in someone else's investigation.

- The problem definition: what do I want to investigate?
- The hypothesis: what do I think the answer might be?
- The materials: what do I need?
- The experiment: what am I going to do?
- The results: what are my observations?
- The conclusion: what conclusion can be drawn?

OBJECTIVE 3

You must be able to name the parts in a diagram of a root system. You must also be able to list the functions of plant roots.

- Root system: all the roots of a plant.
 - Plants in dry environments have larger root systems than plants in moist environments.
- Tap root (in most plants): grows downwards.
 - Lateral roots: branch off from the tap root.
- Root hairs: thin protrusions, often at the ends of roots.
- Functions of the roots:
 - fixing a plant in place in the ground;
 - absorbing water and nutrients (minerals) via the root hairs;
 - storing spare food.

- Because plants absorb nutrients from the ground, the soil may become exhausted.
 - Fertilisation can restore the nutrient levels.

OBJECTIVE 4

You must be able to name the parts in a diagram of a stem. You must also be able to list the functions of plant stems.

- A stem is made up of alternating nodes and internodes.
 - Node: the place where a leaf is attached to the stem.
 - Internode: a section of stem between two nodes.
- Axillary bud: a bud in an axil.
 - Axil: the upper angle between the stem and the leaf.
 - A twig can branch out from the axillary bud the next year.
- Terminal bud: the bud at the end of a stem.
 - A new section of stem with leaves (and flowers) on will grow from the terminal bud next year.
- Functions of stems:
 - keeping the plant upright;
 - transporting water and nutrients through vessels (long thin tubes) that run from the roots right up to the leaves.
- Strength of stems:
 - the stems of herbaceous plants get their firmness from water;
 - the stems of woody plants get their firmness from wood.

OBJECTIVE 5

You must be able to work out the life history of a tree from a cross section through the tree trunk.

- Annual ring: all the wood that is formed in a single year.
 - The oldest wood is in the middle of the trunk.
- You can use the annual rings to work out the life history of a tree.
 - The number of annual rings at the base of the trunk tells you how old the tree was.
 - A broad annual ring shows that the conditions were favourable.
 - A narrow annual ring shows that the conditions were unfavourable.

OBJECTIVE 6

You must be able to name the parts in a diagram of a leaf.

- Leaf stalk: This is what attaches a leaf to the stem.
 - There is an axillary bud at the point where a leaf stalk is attached to the stem.
- Blade: the flat part of a leaf.
 - In simple leaves, the leaf blade consists of a single piece.
 - In compound leaves, the leaf blade consists of a number of leaflets.
- Lamina: all the material that is between the veins.
- Veins (main vein and lateral veins): vascular bundles run through the veins into the blade.
 - The way the veins run through a leaf is called venation.
 - Leaf skeleton: a leaf that no longer has any lamina.

OBJECTIVE 7

You must be able to name the function of leaves.

- The function of leaves is to allow photosynthesis to take place.
- In photosynthesis, water and carbon dioxide are converted into glucose and oxygen.
 - Water is extracted from the soil.
 - Carbon dioxide is absorbed from the air.
 - Glucose is used for making all sorts of other substances, including the substances that plants are made of.
 - Oxygen is released to the atmosphere.
- Light is needed for photosynthesis.
 - Photosynthesis only takes place during the daytime.
- Schematically:

water + carbon dioxide + light → glucose + oxygen

- Photosynthesis takes place in all the green parts of a plant.
- Photosynthesis is important for plants, animals and humans.
 - Photosynthesis makes plants grow, which means that there is food for animals and people.
 - Photosynthesis keeps producing new oxygen.

OBJECTIVE 8

You must be able to state which parts of plants are eaten as vegetables by humans.

- Food crops are the plants that humans use various parts of as food.
- Parts of plants that people use as food:
 - roots;
 - stems;
 - leaves.

OBJECTIVE 9

You must be able to design an experiment.

- An experiment is carried out using several organisms.
 - If just a single organism is used, the results are too likely to depend on random chance.
- In an experiment, you use a test group and a control group.
 - The test group is exposed to the factor you want to investigate, but the control group is not.
 - All the other conditions must be the same.

EXTRA OBJECTIVE 10

You must be able to name the parts of a twig along with their features and their functions.

- Terminal bud with bud scales.
- Axillary bud.
- Dormant buds: buds that do not grow.
- Leaf scars: visible after the leaves have fallen off.
 - The ends of the vascular bundles can be seen in the leaf scar.
- Ring scar: visible after the bud scales of a terminal bud have fallen off.
 - A piece of twig between two successive ring scars grew in a single year.

SKILLS AND COMPETENCIES**BASICS**

- You have learned how to write a report on an experiment.
- You have practised making drawings.
- You have learned how to make a work plan when designing an experiment.

EXTRA

- You have practised making drawings.
- You have learned how to collect the leaves of plants and dry them.

The diagnostic test does not include any questions about these competencies/skills.

You have met a grower in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

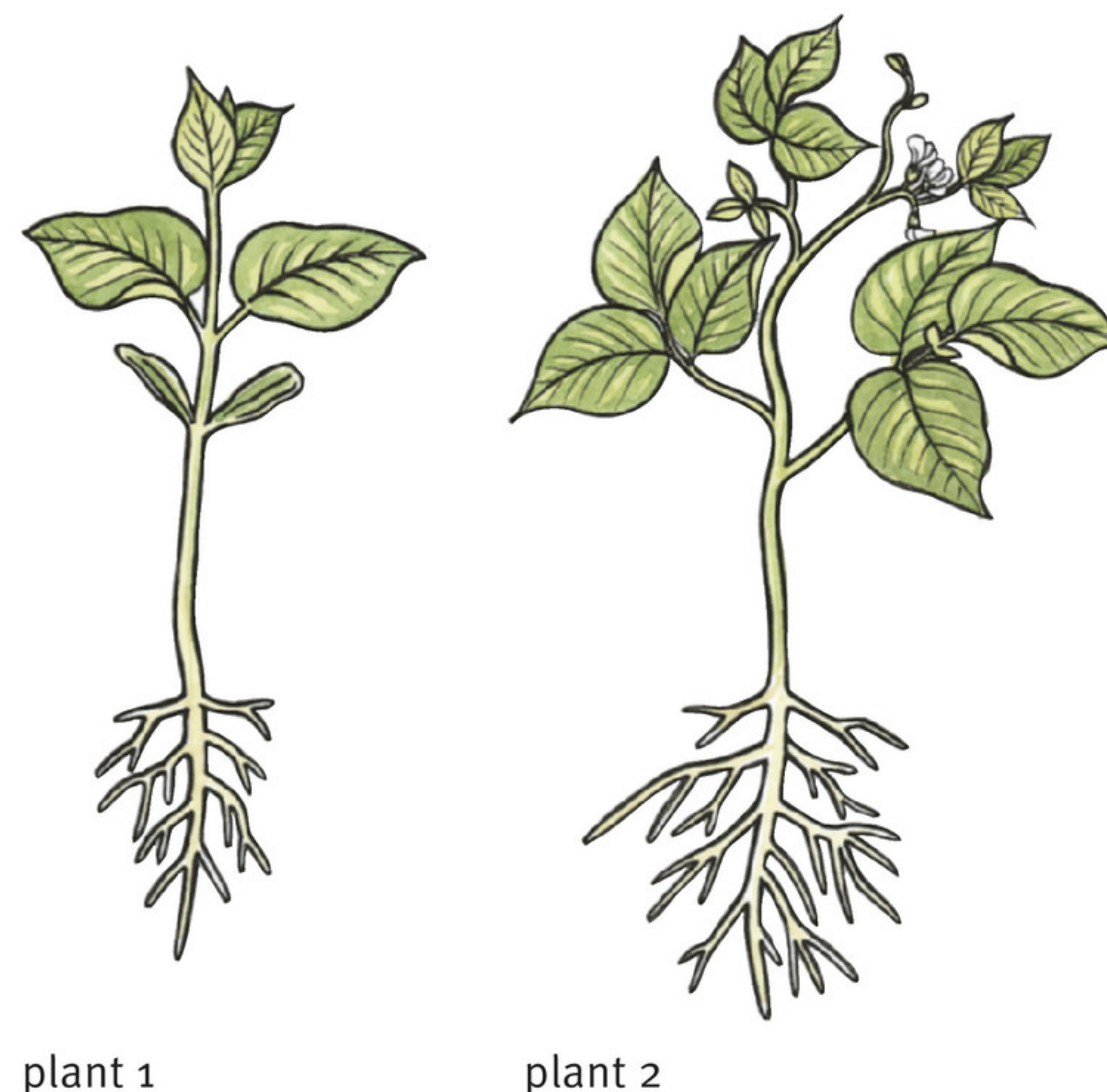
Answer the following multiple choice questions.

- 1 If you want to grow tomatoes, the best approach is to sow the seeds in a seed tray. At about 20°C, the seeds take around ten days to germinate. When the seedlings are strong enough, they can be potted out separately. In May or June, the plants can be put outside in a sheltered place.
What change occurs in the seeds during the first ten days after sowing them?
 - A The seeds get bigger because they are absorbing nutrients.
 - B The seeds get bigger because they are absorbing water.
 - C The seeds get smaller because the seed leaves shrivel up.
 - D The seeds get smaller because they are losing water.
- 2 Here are three things that happen when a seed germinates.
 - 1 The seed coat breaks open.
 - 2 The seed leaves appear above the ground.
 - 3 The root comes out of the seed.
 What is the correct sequence for these events?
 - A 1 – 2 – 3.
 - B 1 – 3 – 2.
 - C 2 – 1 – 3.
 - D 3 – 2 – 1.
- 3 What happens to the seed leaves of a bean during germination and when it starts growing?
 - A The seed leaves grow to become the second pair of leaves.
 - B The seed leaves grow to become seedlings.
 - C The seed leaves absorb water and burst open.
 - D The seed leaves shrivel up and fall off.

- 4 Figure 35 shows you two stages in the lifecycle of a bean plant.
Which of these plants represents a mature bean plant?

- A Neither of the plants.
- B Only plant 1.
- C Only plant 2.
- D Both plants.

▼ Fig. 35



OBJECTIVE 2

When you buy a bunch of flowers, you often also get a sachet of cut-flower food (see figure 36). Sophie wants to investigate whether tulips bloom for longer if they are given cut-flower food.

Figure 37 lists the six steps of her investigation, in random order.

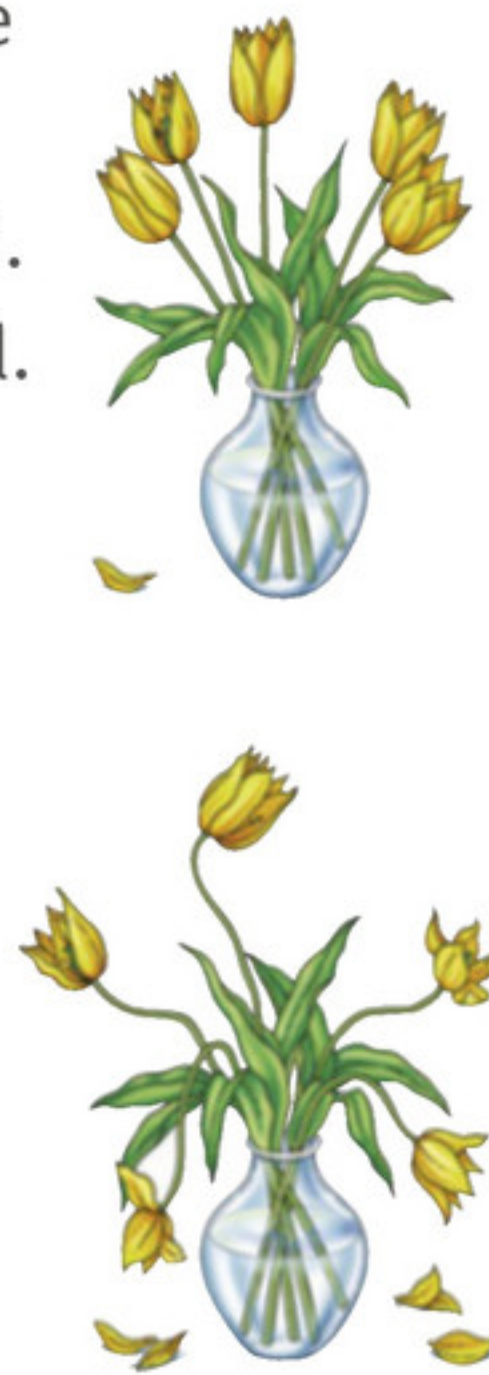
Place the names of the steps after numbers 1 to 6 on your score sheet. Use: *materials* – *conclusion* – *experiment* – *hypothesis* – *problem definition* – *results*.

▼ Fig. 36 Cut-flower food.



▼ Fig. 37

- 1 Sophie takes two identical vases containing the same amount of water. She puts a sachet of cut-flower food in one of the vases. Then she puts a bunch of ten tulips into each of the vases. She makes sure that both bunches of tulips get the same amount of light, air and heat. After five days, she makes a note of how many petals have fallen off each of the bunches.
- 2 Sophie thinks that the tulips will bloom longer if they are given cut-flower food.
- 3 Sophie sees the result and notes it down in her report: tulips bloom longer if they are given cut-flower food.
- 4 Do tulips bloom longer if they are given cut-flower food?
- 5 a sachet of cut-flower food, two vases, water, two fresh bunches of the same variety of tulips
- 6
 - 1 Tulips in water with cut-flower food. One of the tulips has lost one petal.
 - 2 Tulips in water without cut-flower food. Nine of the tulips have lost one or more petals.

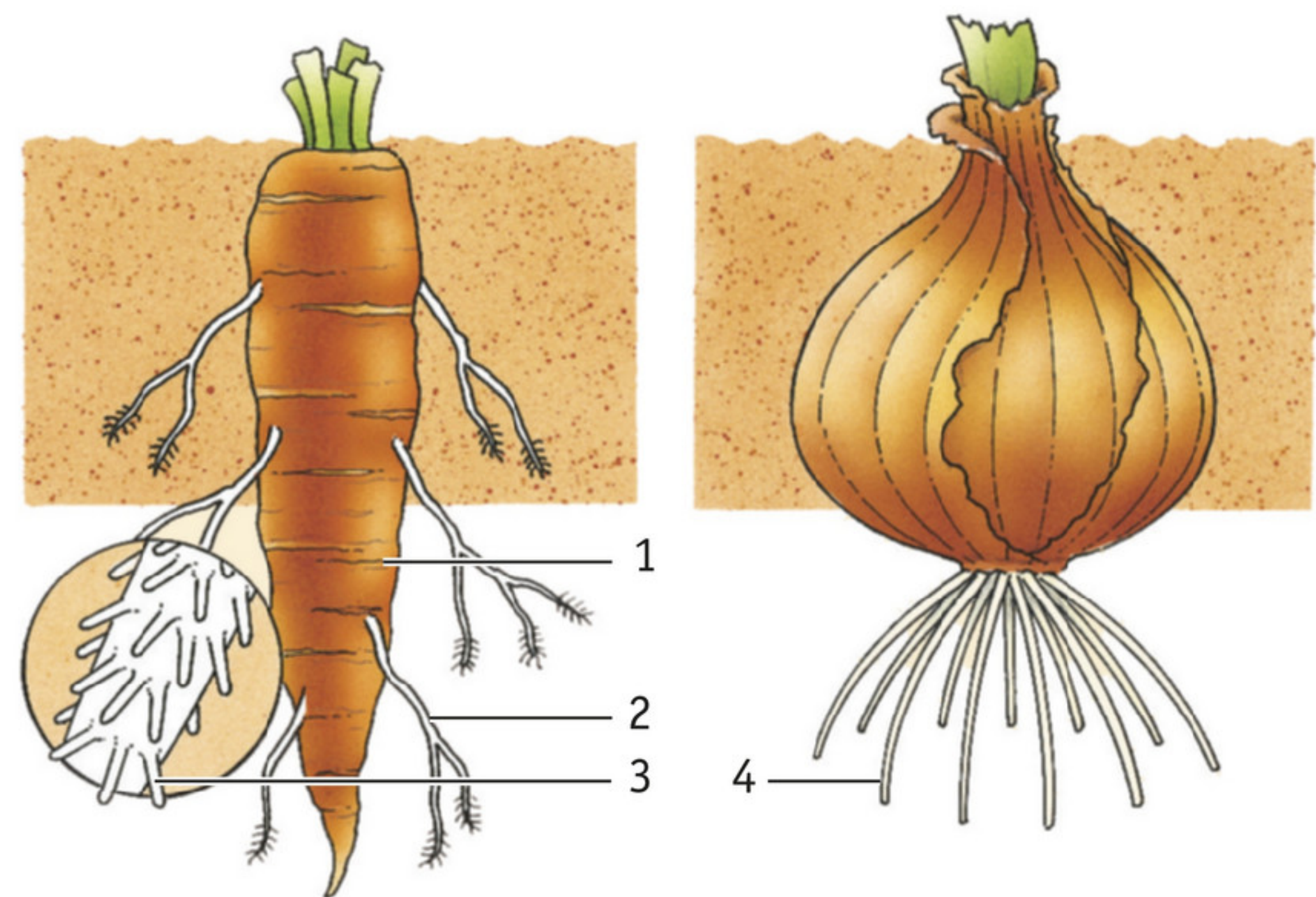
**OBJECTIVE 3**

Answer the questions below.

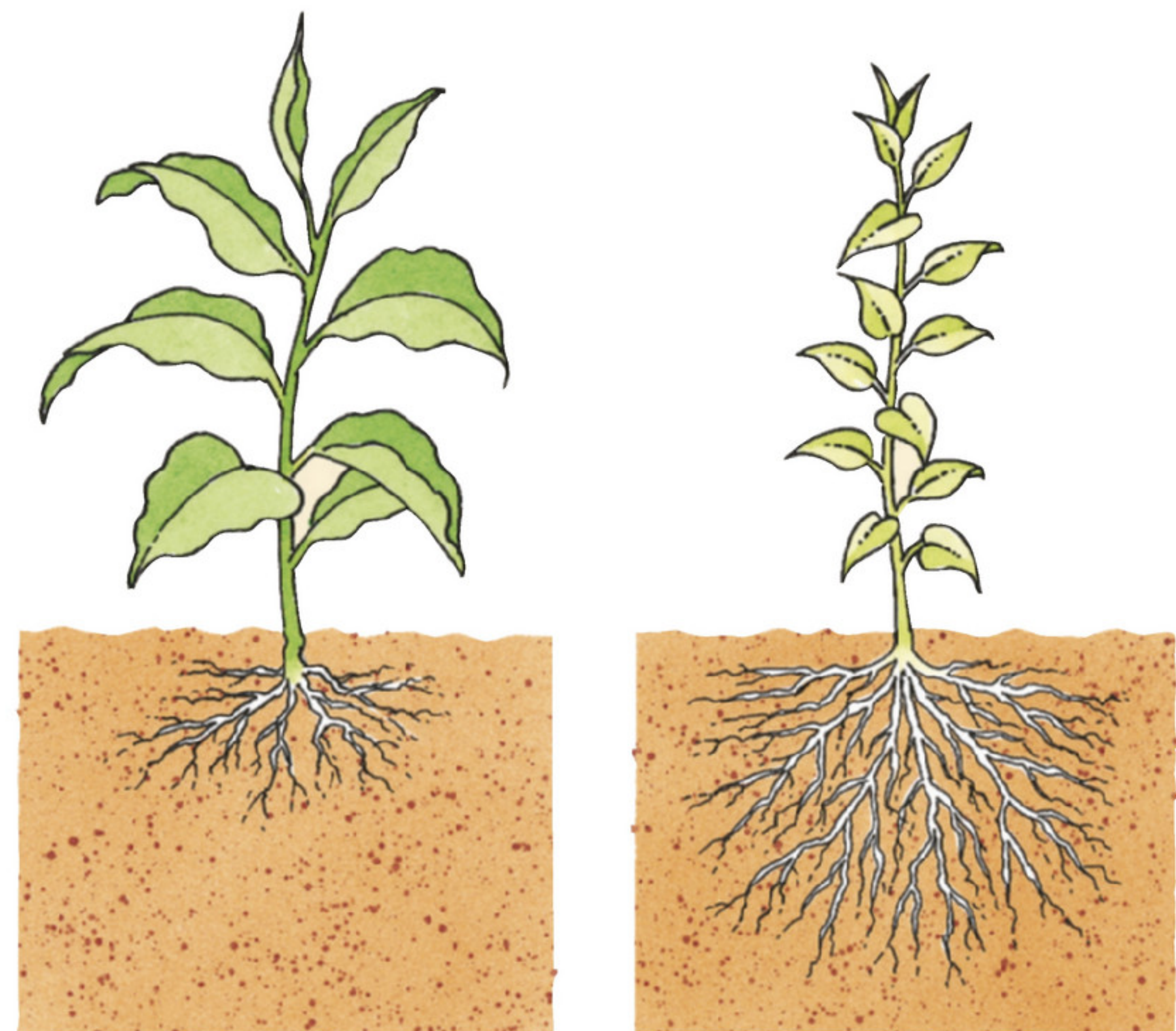
Figure 38 shows a drawing of the root systems of two plants. Questions 1 to 4 are about this figure.

- 1 Which number shows a tap root?
- 2 What does number 3 indicate?
- 3 Can water and nutrients be absorbed at 1?
- 4 Can water and nutrients be absorbed at 4?
- 5 Which two functions of the root are the root hairs involved in?
- 6 Figure 39 shows two plants. Which of the two plants would you think grows in a dry climate? Explain your answer.

▼ Fig. 38



▼ Fig. 39



plant 1

plant 2

OBJECTIVE 4

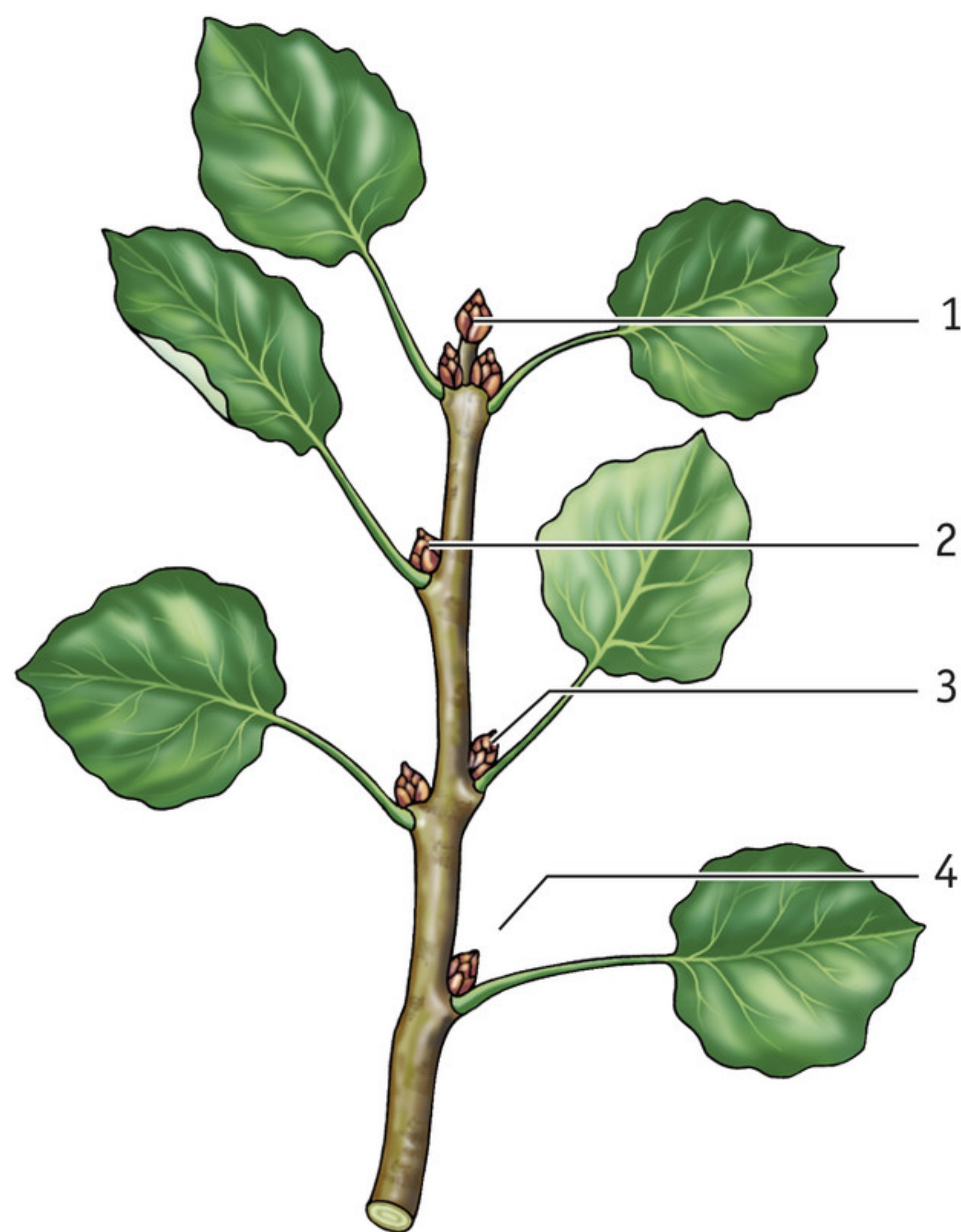
Answer the following multiple choice questions.

- 1 A teacher asks what the benefits are for the plant of having a stem that keeps it upright. Adrian says that the leaves then get more light. Bridget says that the water can then get to the leaves more easily. Who is right?
 - A Only Adrian is right.
 - B Only Bridget is right.
 - C Adrian and Bridget are both right.

Figure 40 shows a drawing of a plant stem. Some parts have been numbered. Questions 2 and 3 are about this figure.

- 2 Which number is an axil?
- A Number 1.
B Number 3.
C Number 4.
- 3 Which of the numbered parts can grow into a new piece of stem with leaves (and flowers) next year?
- A Only part 1.
B Only parts 2 and 3.
C Parts 1, 2 and 3.

▼ Fig. 40



- 4 What gives the stems of herbaceous plants their strength?
- A Wood.
B Herbs.
C Water.
- 5 Are there vessels in all parts of a plant?
- A Yes.
B No, only the stems have vessels.
C No, only the stems and leaves have vessels.

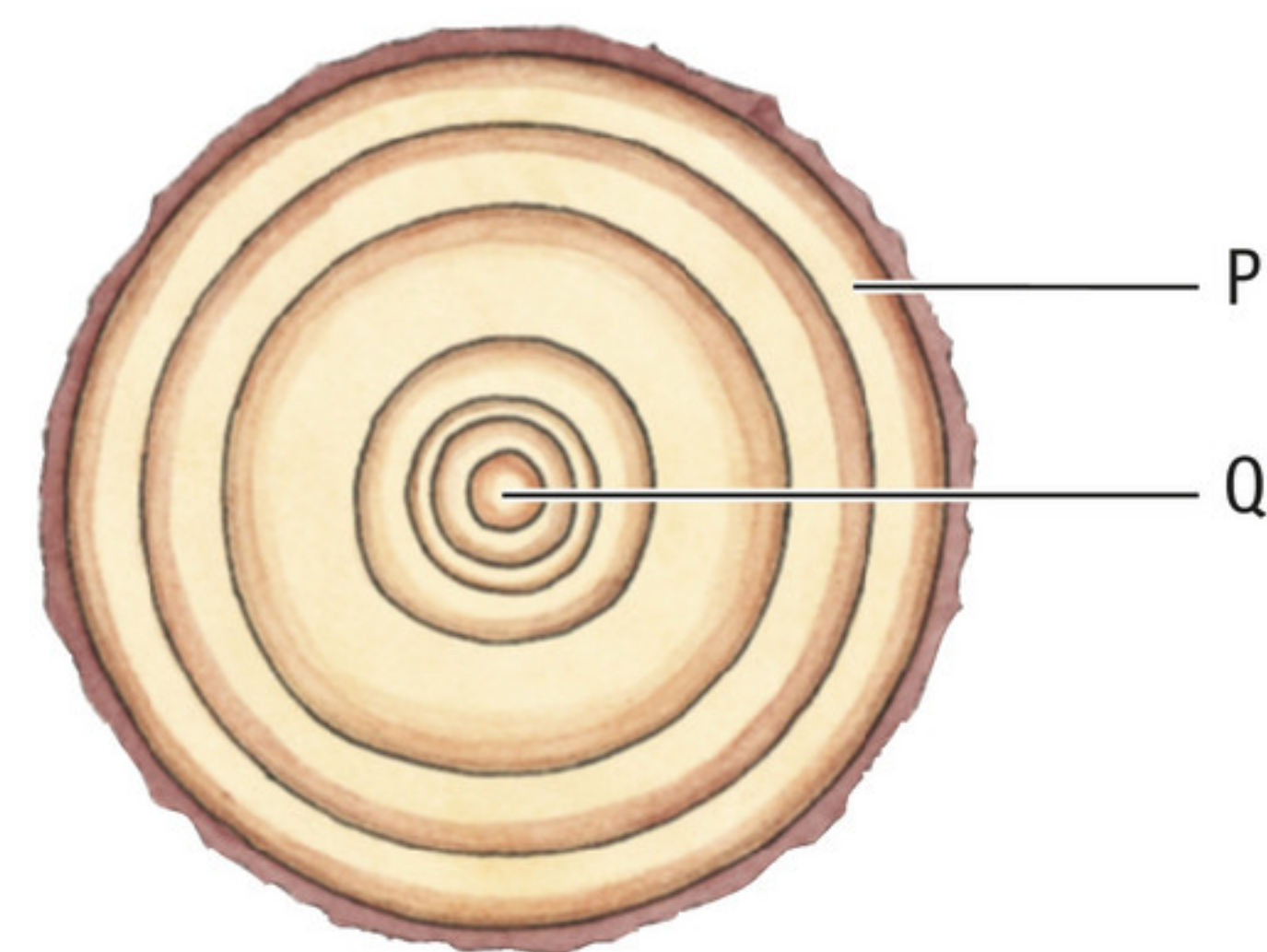
OBJECTIVE 5

Answer the questions below.

Figure 41 shows a cross section of a tree trunk that was cut down in the autumn of 2012.

- 1 Which letter points to the oldest wood, P or Q?
- 2 How old did this tree get (at least)?
- 3 In which year were the environmental conditions most favourable?
- 4 And in which year were they least favourable?
- 5 What do we call all the wood that is produced in a single year?
- 6 Why does an annual ring have a lighter section and a darker section?

▼ Fig. 41

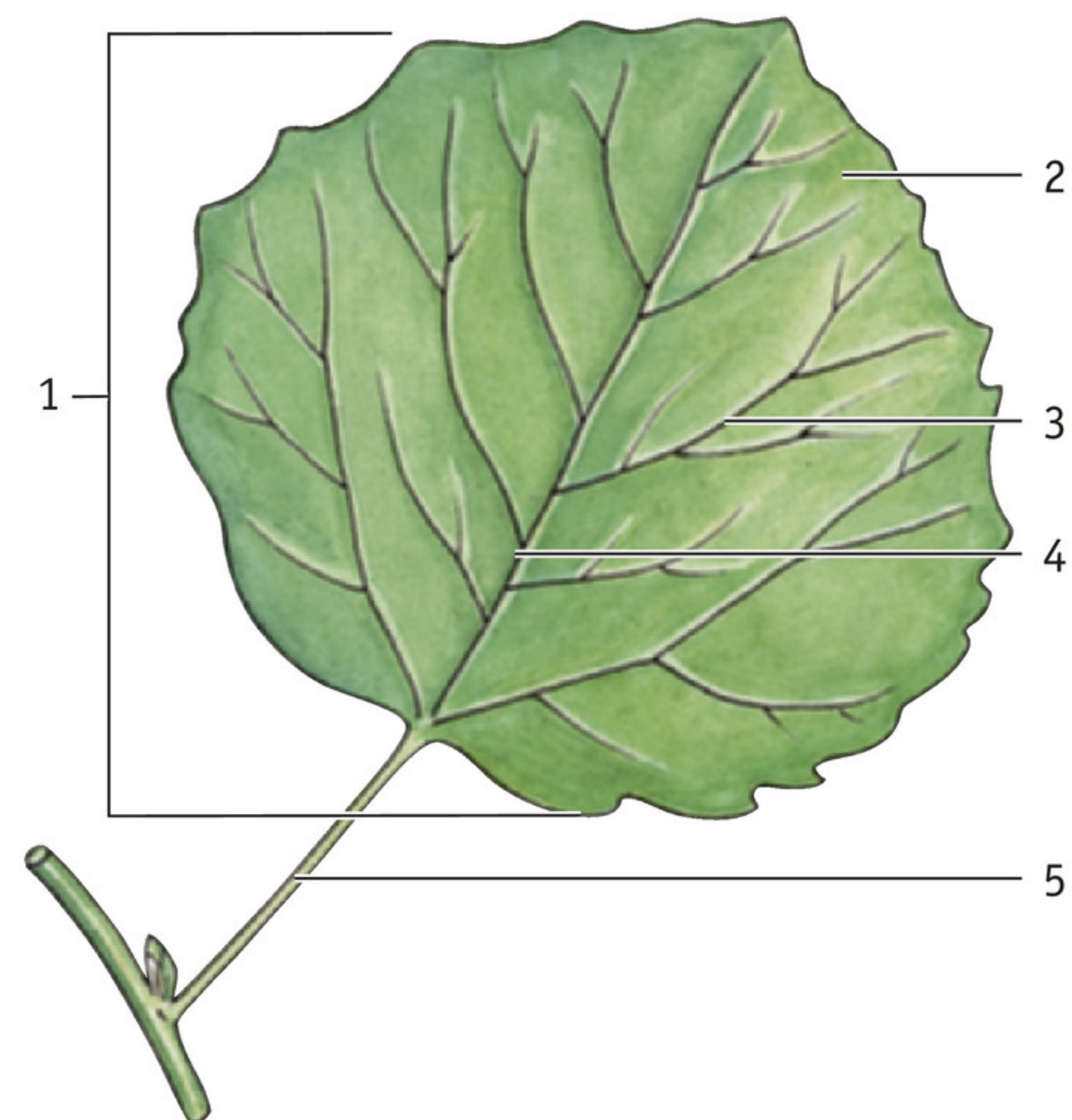


OBJECTIVE 6

Figure 42 is a drawing of a leaf.

State the names of the numbered parts.

▼ Fig. 42



OBJECTIVE 7

Answer the following multiple choice questions.

- 1 What substances does a plant need for photosynthesis?
 - A Glucose and carbon dioxide.
 - B Glucose and oxygen.
 - C Water and carbon dioxide.
 - D Water and oxygen.
- 2 Figure 43 shows a greenhouse with tomato plants. At what time of day will the amount of oxygen in the greenhouse be greatest? Or is there always roughly the same amount of oxygen in the greenhouse?
 - A There is always roughly the same amount of oxygen in the greenhouse.
 - B The amount of oxygen in the greenhouse is highest early in the morning.
 - C The amount of oxygen in the greenhouse is highest in the middle of the day.
 - D The amount of oxygen in the greenhouse is highest at the end of the day.

▼ Fig. 43



- 3 Figure 44 contains a fragment of text about tissue culture. During an experiment, a number of pots are placed in the light and another set are put in the dark. The other conditions are kept the same. In which pots will the oxygen level have increased after a few hours? And in which pots will glucose have formed in the plants after a few hours?

The oxygen level is higher in

- | | |
|--|--|
| <ol style="list-style-type: none"> A pots standing in the light. B pots standing in the light. C pots standing in the dark. D pots standing in the dark. | <ol style="list-style-type: none"> A pots standing in the light. B pots standing in the dark. C pots standing in the light. D pots standing in the dark. |
|--|--|

▼ Fig. 44

Tissue culture

Plant tissue culture gives growers the possibility nowadays of cultivating large numbers of plants that all look the same. This is often done using axillary buds. These are placed in a special nutritional medium in glass pots. The pots are closed off to make sure that no insects or bacteria can get inside the pots and attack the plants.

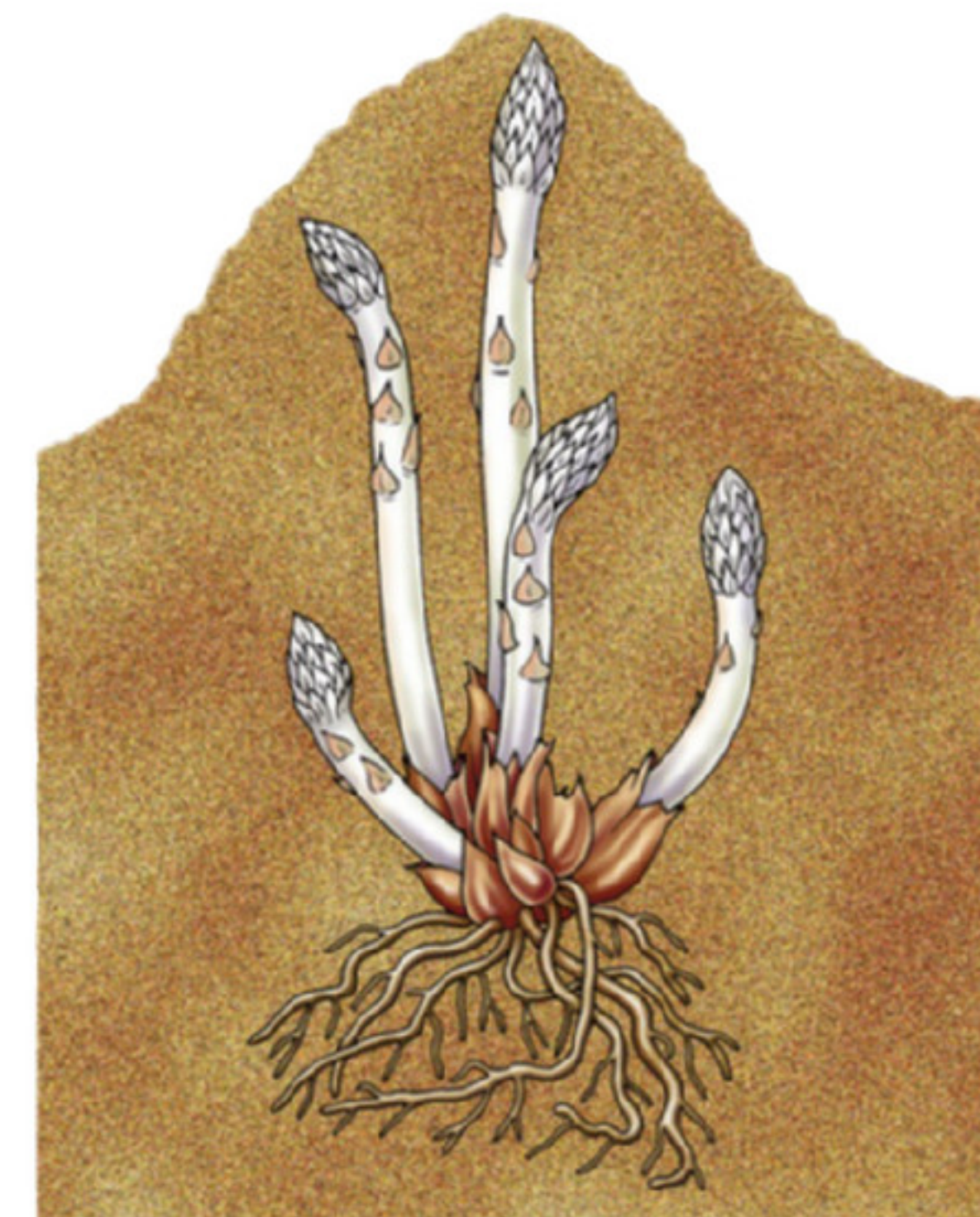


- 4 The asparagus plant (see figure 45) is popular because the young, white stems are edible. They grow up from a root that is deep in the ground. This makes the asparagus stems longer, and keeps them white.

Is photosynthesis taking place in the asparagus stems? And is photosynthesis taking place in the roots?

 - A Photosynthesis is not taking place in either of them.
 - B Photosynthesis is only taking place in the roots.
 - C Photosynthesis is only taking place in the stems.
 - D Photosynthesis is taking place in both the roots and the stems.

► Fig. 45



- 5 How does a plant that grows on land get its water? And where does it get carbon dioxide from?

A Water is absorbed from the soil and carbon dioxide from the air.
B Water is absorbed from the air and carbon dioxide from the soil.
C Water and carbon dioxide are both absorbed from the soil.
D Water and carbon dioxide are both absorbed from the air.

- 6 A schematic representation of photosynthesis is given below. Two words have been replaced by numbers.



What needs to be filled in at 1? And what belongs at 2?

	At 1	At 2
A	glucose.	nutrients.
B	carbon dioxide.	glucose.
C	nutrients.	glucose.
D	nutrients.	carbon dioxide.

OBJECTIVE 8

Say whether each of the following statements is true or false.

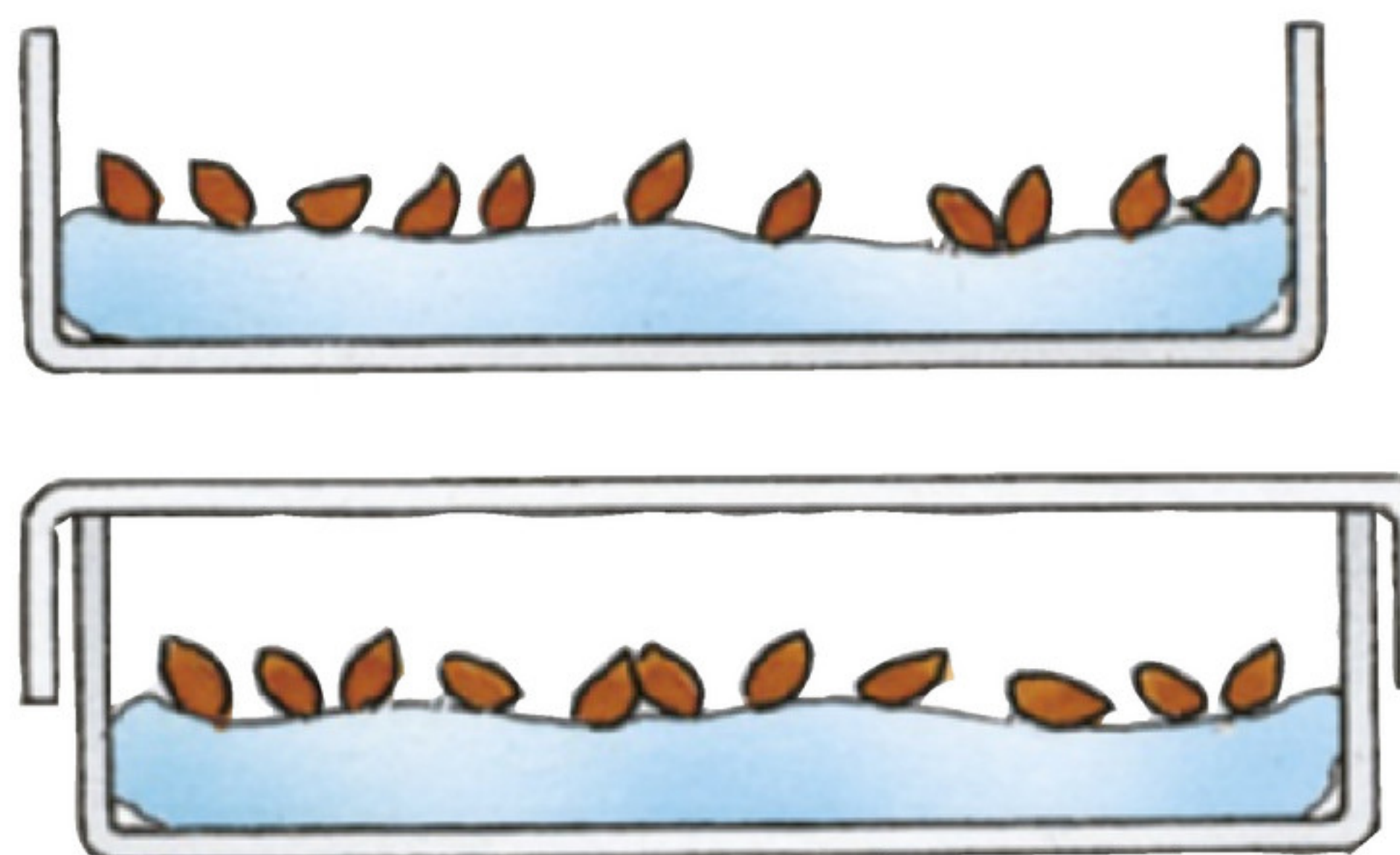
- 1 Lettuce is a food crop.
- 2 Attention is paid to the taste and the yield in the cultivation of food crops.
- 3 Cultivating food crops has made most food crops smaller.
- 4 Humans do not use the roots of plants as food crops if the parts of the plant that are above ground die off in the winter.
- 5 Red cabbage is a food crop that we eat the leaves of.
- 6 When you eat potatoes, you are eating part of the potato root.

OBJECTIVE 9

Answer the following two-choice questions.

- 1 Karen is investigating the effect of temperature on the germination of seeds. She has put seeds in two dishes. She has stored the dishes as shown in figure 46.
Can Karen draw any conclusions about the effect of temperature on the germination of seeds when she has completed her experiment?
A Yes.
B No.

▼ Fig. 46



The following information is for questions 2 and 3. Some seeds contain disease germs (pathogens). The companies that sell seeds sometimes heat-treat the seeds, with the aim of killing off the pathogens. An experiment is done to see whether the seeds of the mustard plant (see figure 47) still germinate properly after heat treatment. The test group consists of a glass tube containing twenty seeds. The glass tube is placed in an oven set to 50°C for half an hour. It is dark in the oven.

▼ Fig. 47



- 1 mustard plant
- 2 The control group also consists of a glass tube containing twenty seeds.
At what temperature should the control group be stored?
A At room temperature (roughly 20°C).
B At 50°C.

- 3 After heating, the ability of the seeds to germinate is measured. The twenty seeds from the test group are spread over a glass dish of damp cotton wool. The dish is left in the light.

The twenty seeds from the control group are also spread over a glass dish of damp cotton wool. Should the control group dish be placed in the dark or in the light?

- A In the dark.
- B In the light.

Apple pips are seeds. An experiment is being done to see whether apple pulp affects the germination of apple pips.

Moist cotton wool has been laid in the bottom of a dish. Apple pips and pieces of apple have been placed on the cotton wool.

Only moist cotton wool has been placed at the bottom of a second dish.

- 4 What should be placed in the second dish as the control group?
- A Only apple pips.
 - B Apple pips and pieces of apple.

EXTRA OBJECTIVE 10

Say whether each of the following statements is true or false.

Figure 48 is a picture of a twig in winter. A new section grows on this twig the next year.

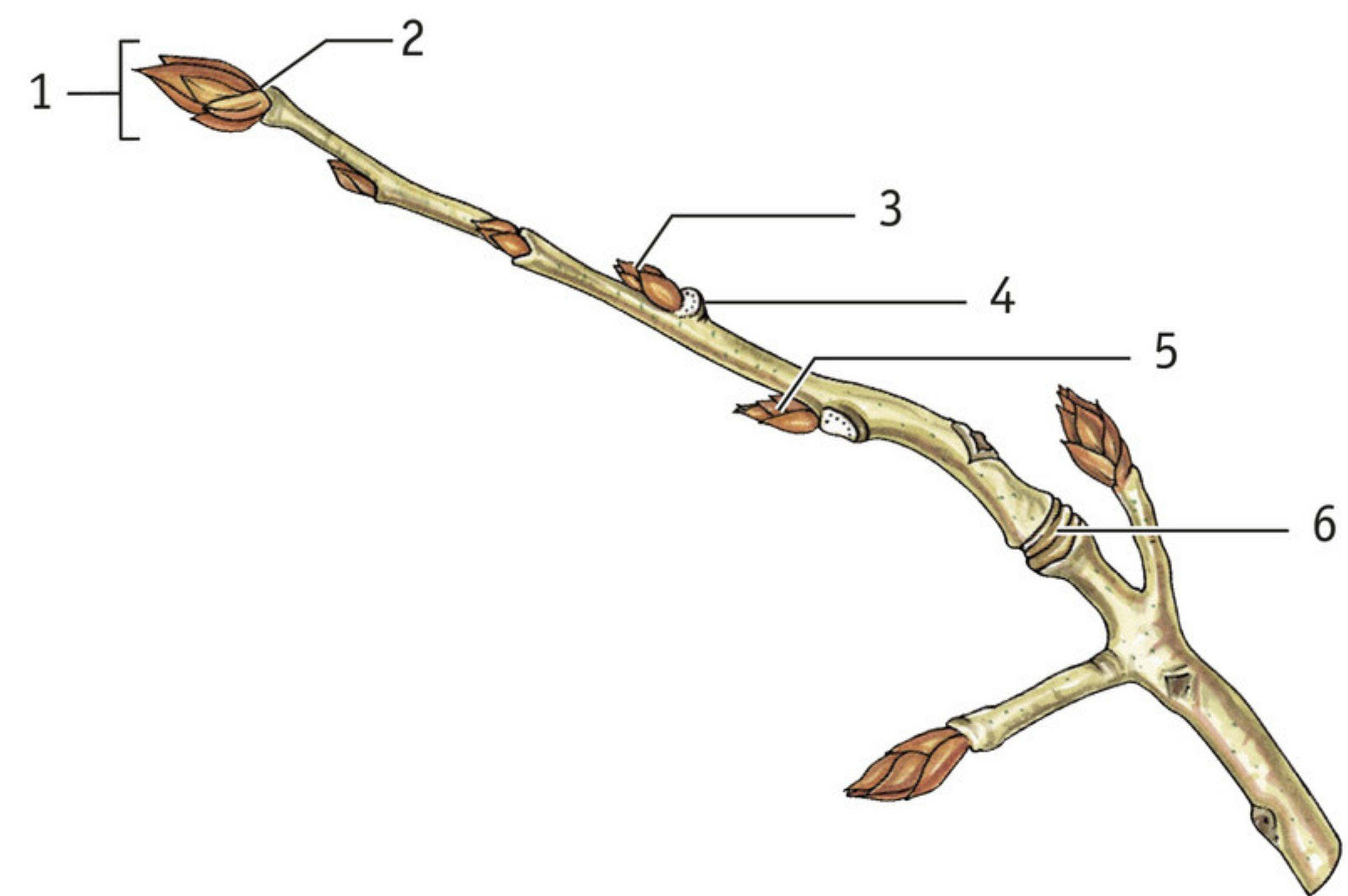
- 1 The new piece could have grown from part number 1.
- 2 A ring scar will be visible at 2 next year.

- 3 There were once bud scales of a terminal bud at position 4.
- 4 The ends of vascular bundles can be seen at position 4.
- 5 Part 6 is a leaf scar.
- 6 The section of twig between numbers 2 and 6 grew in a single year.

The bud labelled 5 is still on the twig a year later, unchanged. This bud has not grown any further.

- 7 This type of bud is called a dormant bud.
- 8 This bud will only start to grow if bud 3 starts to grow at the same time.

▼ Fig. 48



You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three parts. You can do the exercises for them in your workbook. Your teacher will tell you how many parts you should choose.

1 Sprouts and shoots

Sprouts or shoots (not to be confused with Brussels sprouts) are seedlings that we eat. Familiar ones are cress, alfalfa and beansprouts. Red cabbage, rocket, sunflowers and pumpkins are others that can be eaten as sprouts (see figure 49).

Sprouts and shoots are being used increasingly often, for example in salads. Sometimes they are there as decoration, but they are also often used for giving extra taste to a dish.

Because sprouts and shoots are nothing more than seedlings, they can be grown quickly and easily. Most kinds of sprouts can be harvested and eaten after about one week.

In this extension you are going to grow and draw a seedling. If several pupils are doing this exercise, you could agree to grow different sprouts. You can then compare the taste of the different shoots and sprouts.

WB EXERCISE 1, PAGE 62

▼ Fig. 49 Sprouts and shoots.



2 The importance of photosynthesis

In the Basics, you learned that plants can make glucose through photosynthesis. You have also learned that plants can convert glucose into other substances. In this extension, you will find out how humans depend in all kinds of ways on products from raw materials that are ultimately derived from photosynthesis. You will be answering questions about this.

In Basics 4, you already learned that photosynthesis is continually refreshing the **oxygen** in the air. You also learned that photosynthesis continues to create new sources of **food** on Earth. Photosynthesis has also played a role in a lot of the **energy** that we use. Petroleum, coal and natural gas, for example, are all formed from the remains of organisms that were once alive. The substances that made these ancient organisms are ultimately derived from photosynthesis.

Figure 50 shows you a diagram of a home. The house is heated by burning natural gas. The car and the moped in the figure run on petrol. Petrol is made from petroleum – oil from the ground. Household appliances such as the fridge and washing machine use electricity, as does the lighting in the house. Electricity is generated at power stations, which use natural gas or coal as their fuel.

Photosynthesis has also played a part in many **raw materials**. Oil can for instance be used to make plastics. Many items are made at least partly out of plastic, such as a mobile phone or a TV. In addition, many products contain substances that are made from plants, animals or petroleum products. There are examples of such products in figure 50 too, such as cosmetics and roofing felt.

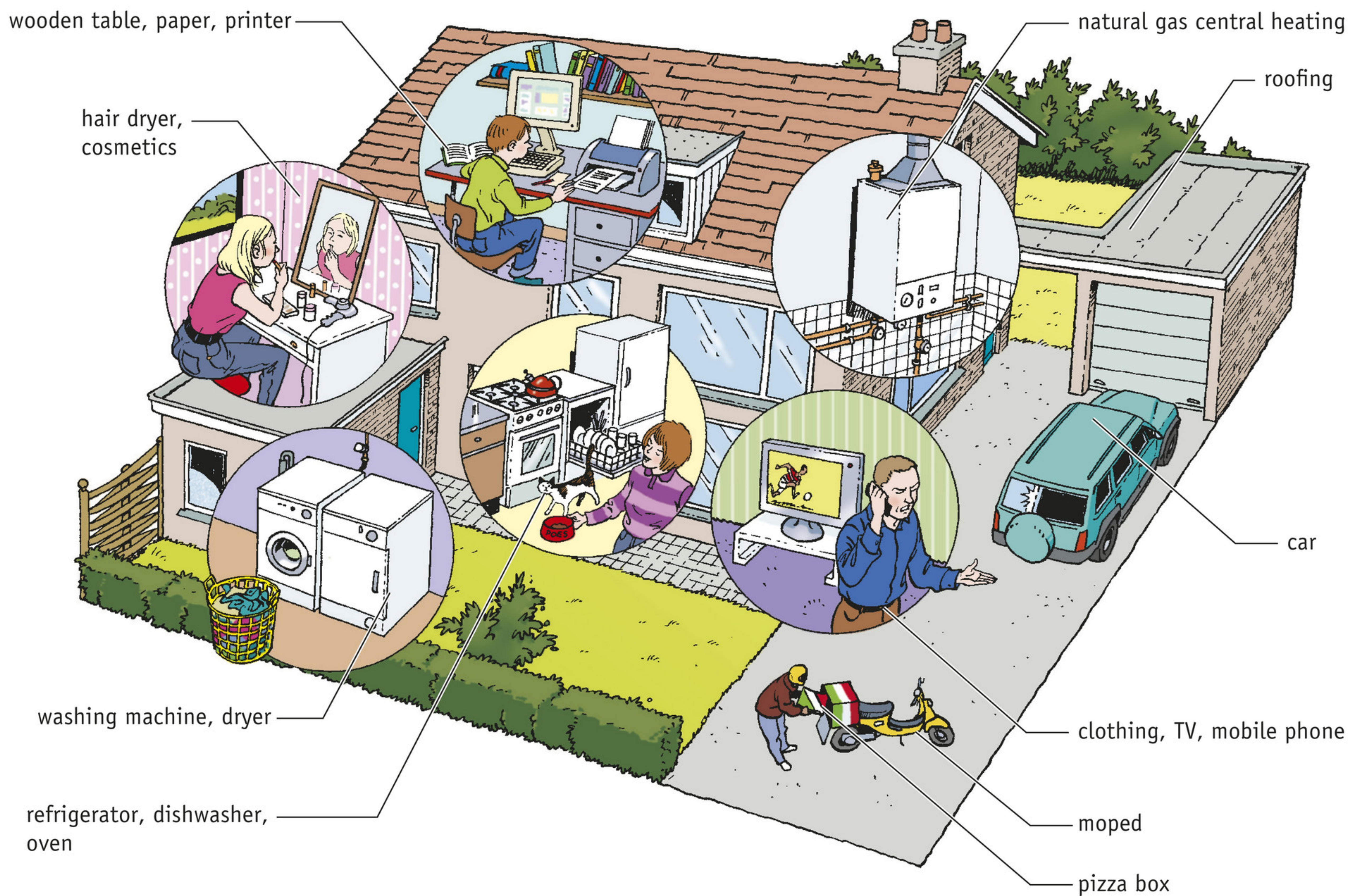
The people in figure 50 are wearing cotton clothing. A cotton plant is able to produce glucose by photosynthesis, and then use the glucose to produce the fluff around its fruits. This fluff is used in turn to make cotton. Flax is another crop that is used for making textiles. The fibres of flax plants are used to make linen.

Textiles can also come from animals, for example a woolly jumper or a silk tie. Wool is made from animal fleece. Silk comes from the cocoon of the silkworm. A silk cocoon is a shell made of silk threads. Our footwear is often made of leather, which comes from animal skins. Animals depend on food that is made by plants by photosynthesis.

Another widely used raw material is wood. Photosynthesis also plays a role in the production of wood. Wood can be used in a wide variety of ways, for instance in furniture or toys. Many buildings are partly made of wood. Wood can also be used to make paper. Not all substances are derived from photosynthesis, though. Stone, water and metals are not, for instance.

WB EXERCISE 1, PAGE 63

▼ **Fig. 50** Photosynthesis has played a part in the production of fuels that provide energy and of the raw materials for various products.



3 Insect galls

▼ **Fig. 51** A gall wasp.



You sometimes see small balls or beads on the leaves of some trees. These beads are called **galls**. This extension teaches you what galls are and how they occur. You will answer questions and collect and draw insect galls.

A gall (see figure 51) is formed where a **gall wasp** lays an egg on the leaf of a tree. Larvae come out of the eggs and start eating the leaf. The tree protects itself against the eggs and the larvae. A casing grows from the leaf of the tree, enclosing the eggs.

A gall develops around each egg. Inside the gall, the egg develops into a larva and then a gall wasp. The gall provides protection and food for the larva.

When the gall wasp is mature, it crawls out of the gall.

You can often find galls on the leaves of an oak or a beech in the autumn (see figure 52). The casing of an oak gall is very tough, but in every oak gall there is one spot that is less hard. You can find it with a pin. This softer spot is where the gall wasp comes out.

WB EXERCISES 1 AND 2, PAGE 65

▼ **Fig. 52** Galls.



1 oak apples



2 beech galls

3

Organs and cells



BASICS

- 1 Organs and tissues
- 2 The microscope
- 3 Microscopy
- 4 Cells
- 5 The nucleus
- 6 Levels of biology

EXTRA

- 7 Cell division
- 8 Stomata

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- 2 Organ systems in a dog 110
- 3 Organ systems in an insect 111



This unit is called 'Organs and cells'. In this unit, you will learn that organisms are made up of cells. The organs in your body perform certain functions. You will learn about some of these organs and their functions.

In this unit, you will learn how to use a microscope and you will look at the structure of cells. You will also learn what chromosomes are and what DNA is.

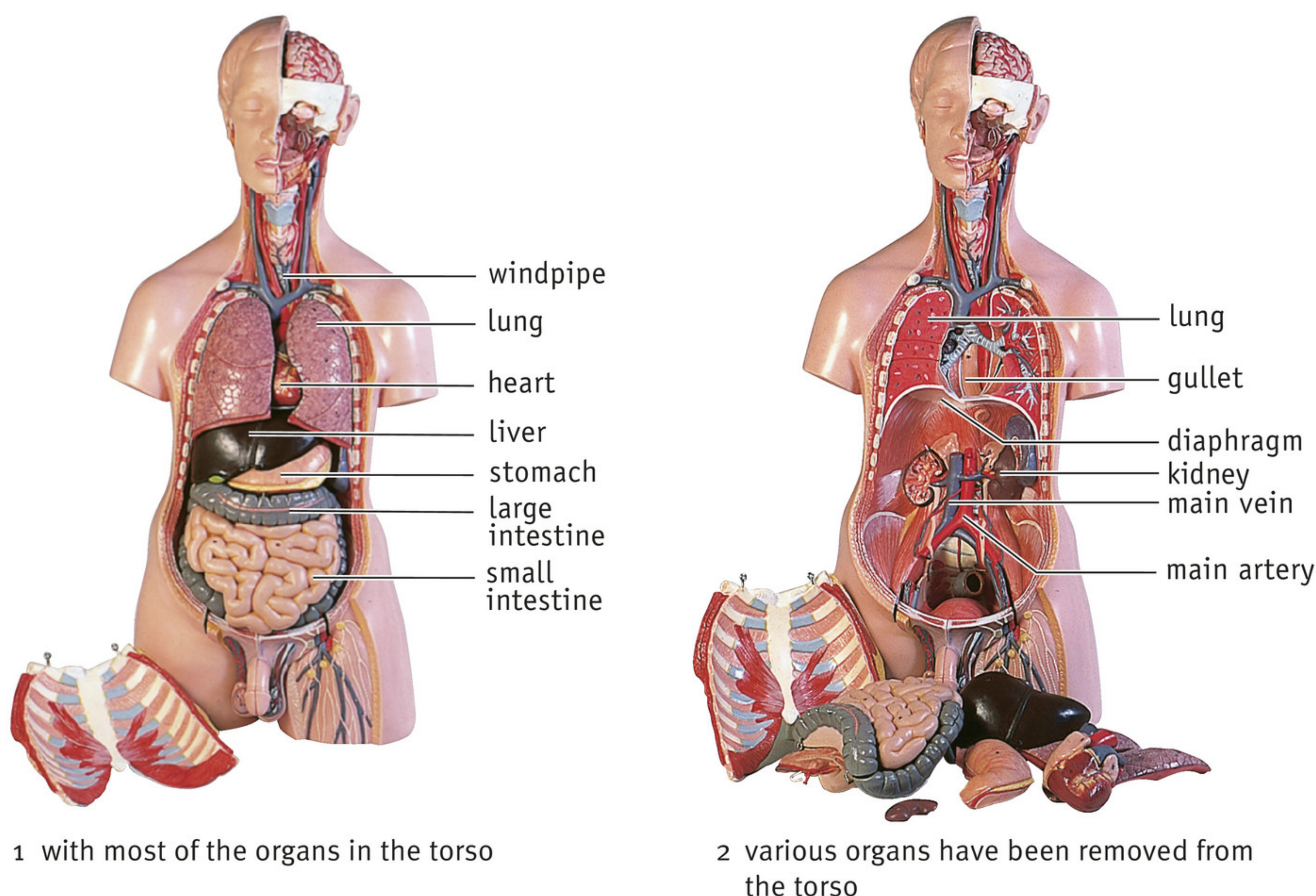
Cells, organs and organisms are examples of different levels in biology. You will also learn what levels there are in biology.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

1 Organs and tissues

Figure 1 shows a model of the torso and head of a man. You can see the position of various **organs** and what they look like. Organs are parts of an organism that perform certain tasks. The skin protects the body, for example, and the heart makes sure blood keeps on flowing in the blood vessels. Some organs have more than one function. The skin does more than just protect humans: it also plays an important role in regulating body temperature. Plants have organs too. Roots, stems and leaves are all plant organs.

▼ Fig. 1 Torso.



ORGAN DONATION

Often people become sick because an organ is not functioning properly. In such cases, an **organ donation** can sometimes save someone's life (see figure 2). You can register as a donor from the age of 12. That means you say that your organs can be used after your death to save someone else's life. If you are under 16, your parents still have to give permission. Younger children are not allowed to register. If they die, their parents or foster parents decide whether their organs should be donated. If someone dies and is not registered, the doctor will ask their relatives for permission. There is still a severe shortage of organ donors, so there are campaigns every year to recruit more donors.

WB EXERCISES 1 TO 3, PAGE 68

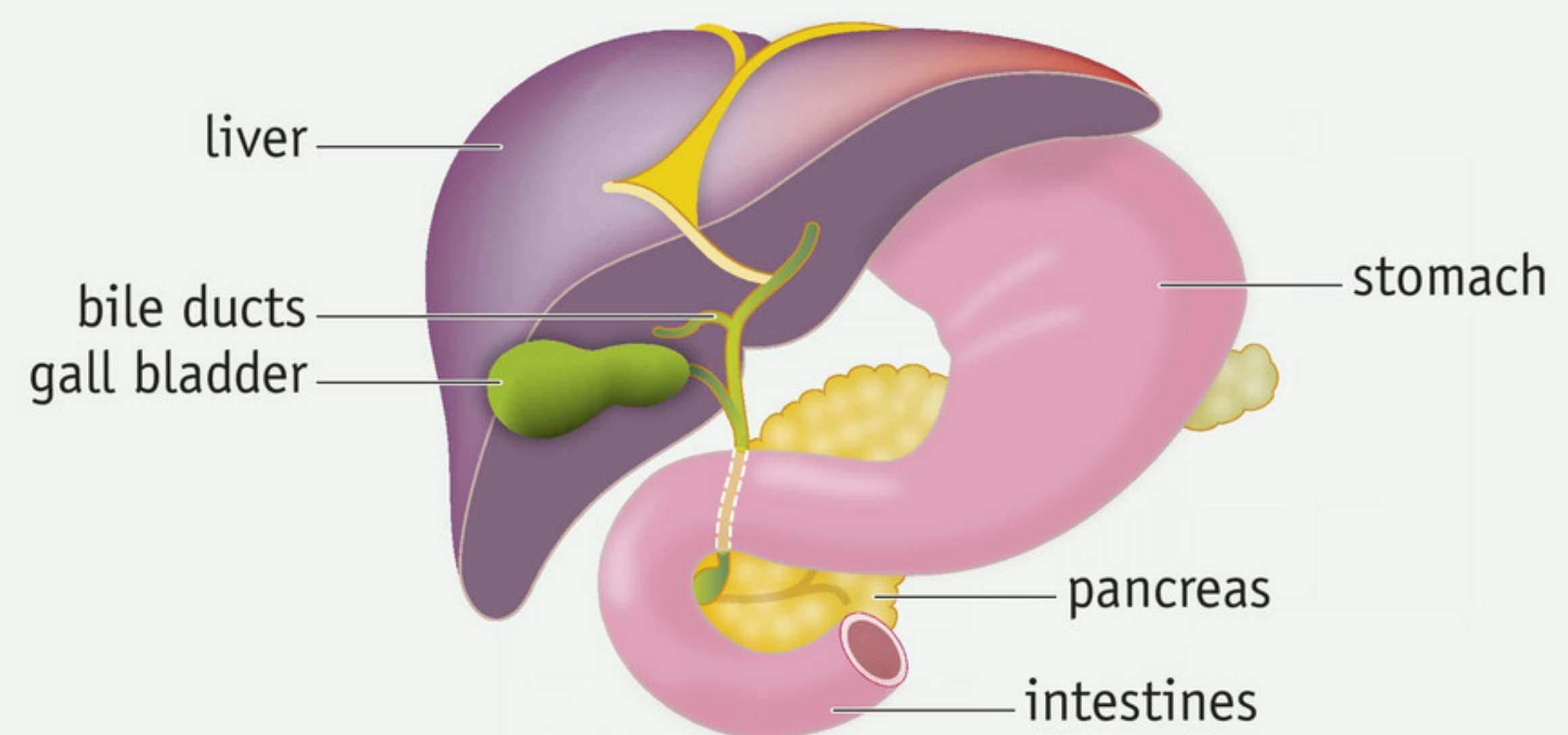
▼ Fig. 2 Organ donation.

Waiting for a liver

When Lydia was born, it turned out her liver was not functioning properly. Your liver regulates the composition of the blood, among other things. Waste products are produced in the liver and enter the gall bladder via the bile ducts before entering the intestines (see the figure). Lydia's bile ducts turned out to be blocked. As a result, waste products accumulated in the liver, causing damage.

Fortunately, Lydia's problem was soon discovered. An operation was carried out to make a new duct. This worked well at first, but after a few years her liver began to function less well. When Lydia was 5, she was put on the organ donation list. It took nearly a year for a suitable liver donor to be found. The operation

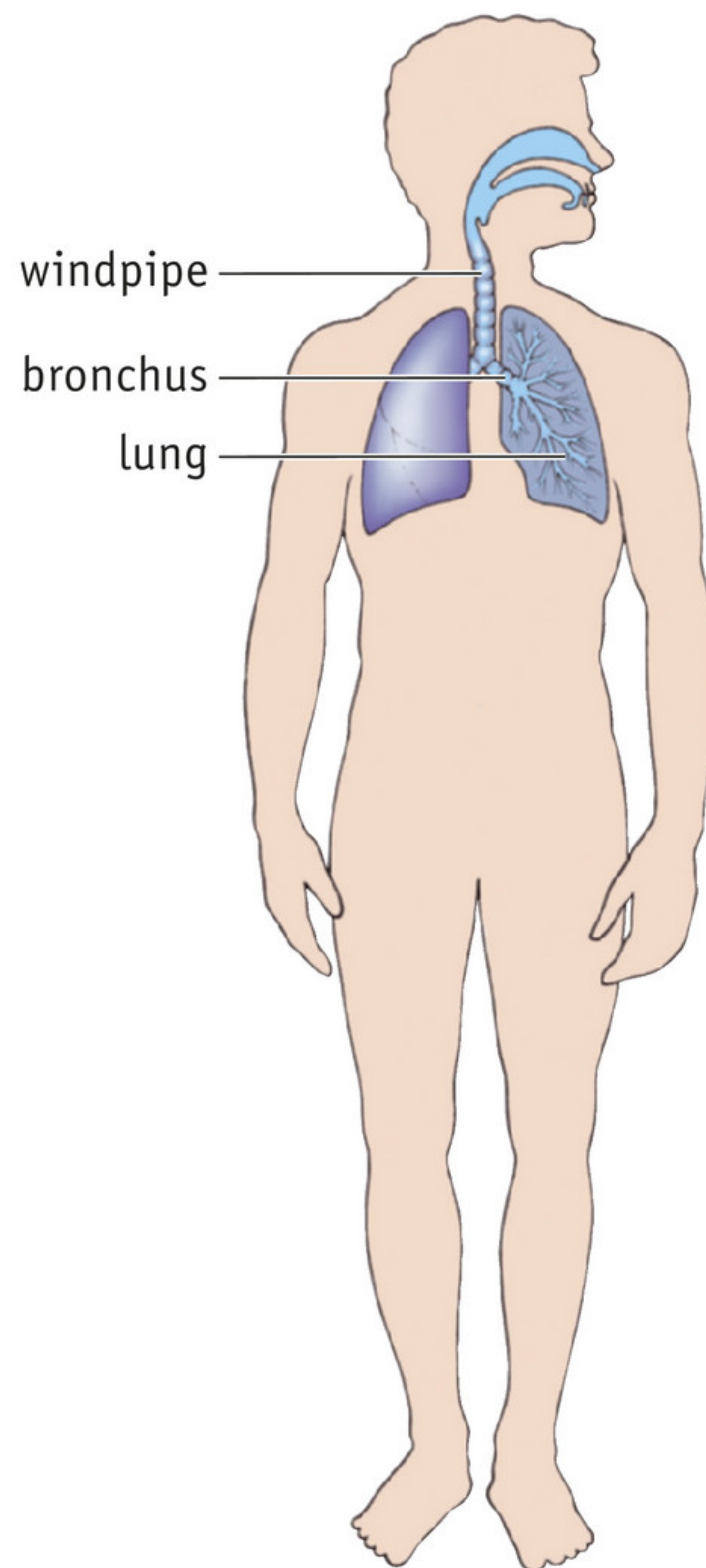
went well and Lydia's body did not reject the new liver. Lydia has been able to lead a normal life since the transplant.



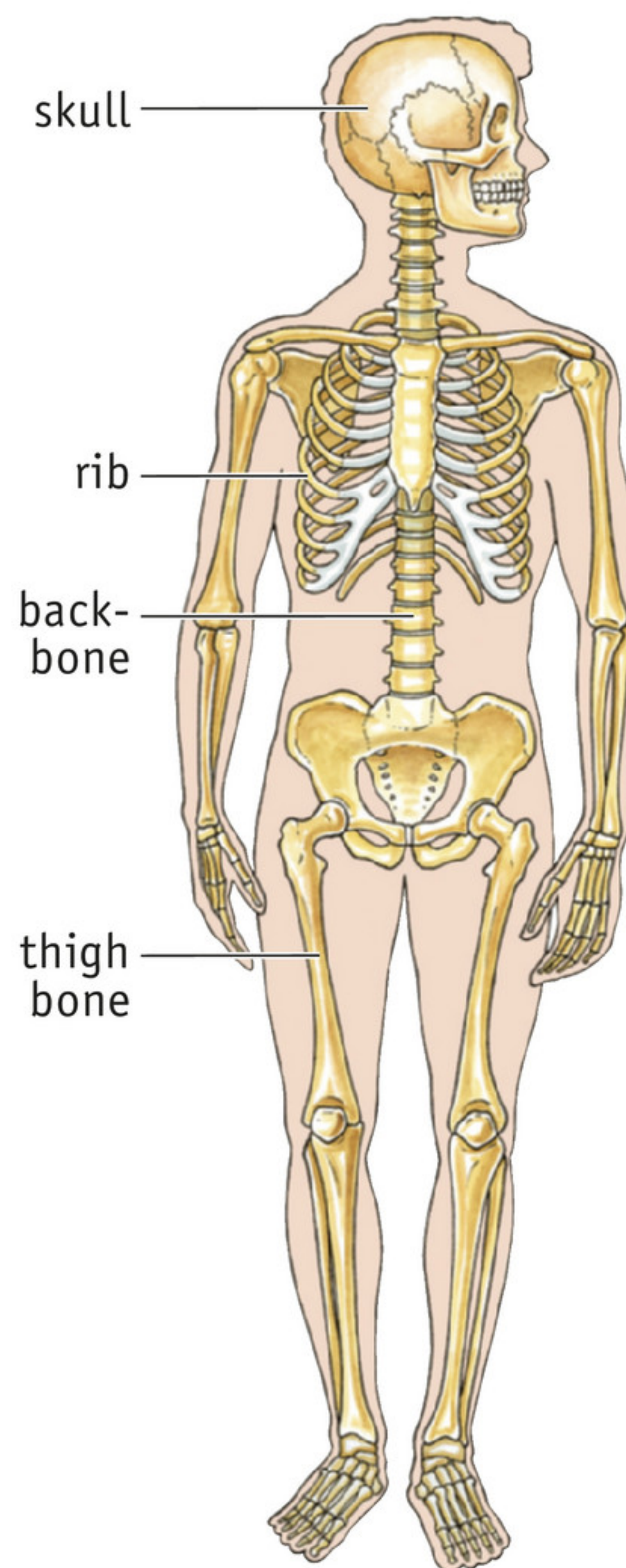
ORGAN SYSTEMS

Organs often work together to perform a certain task. We call such a group of organs an **organ system**. You need your heart and all your blood vessels for the circulation of your blood in your body. Together they form the circulatory system. Other organ systems in humans are the respiratory system, the skeletal system, the muscular system, the digestive system and the nervous system (see figure 3).

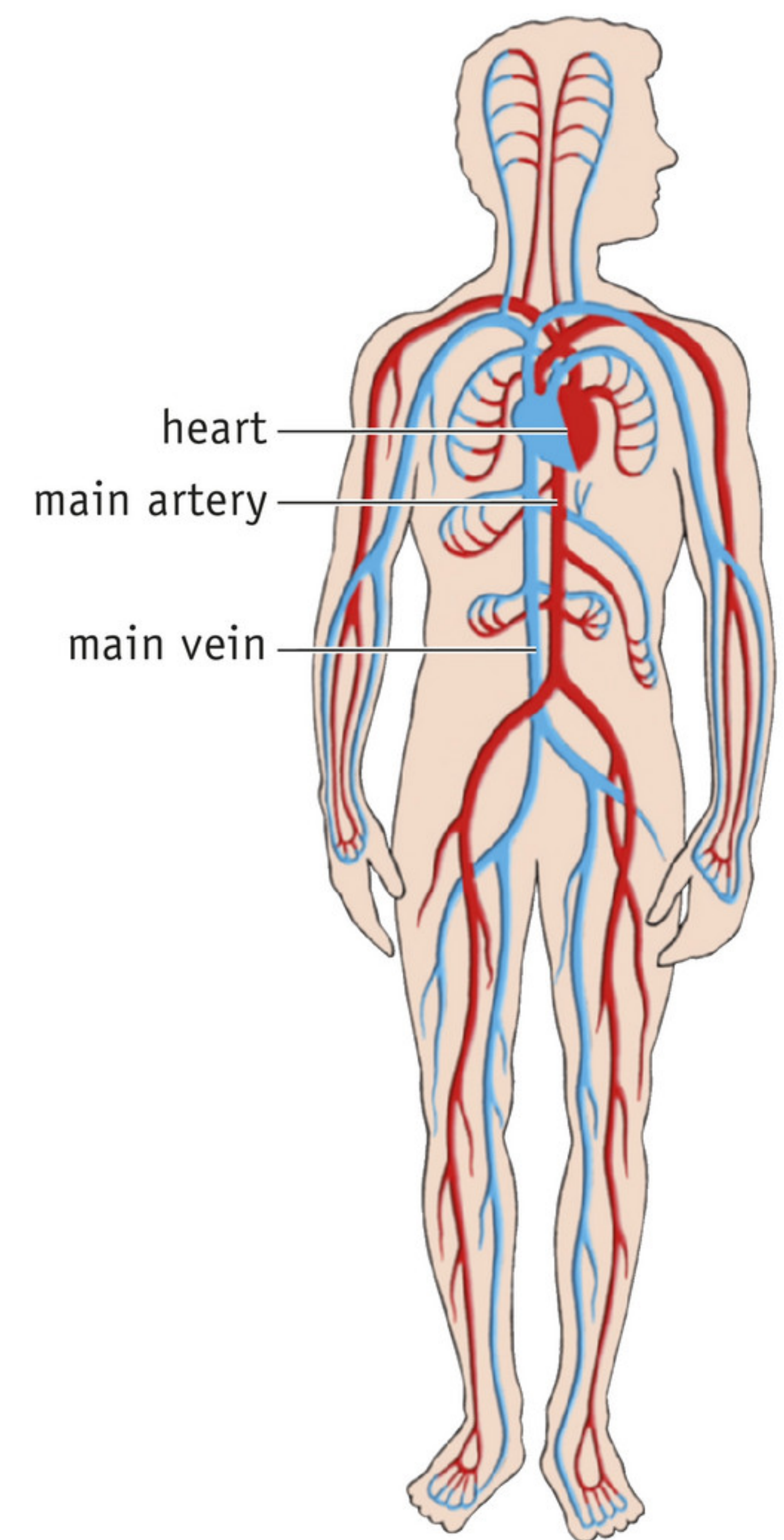
▼ Fig. 3 Organ systems in humans.



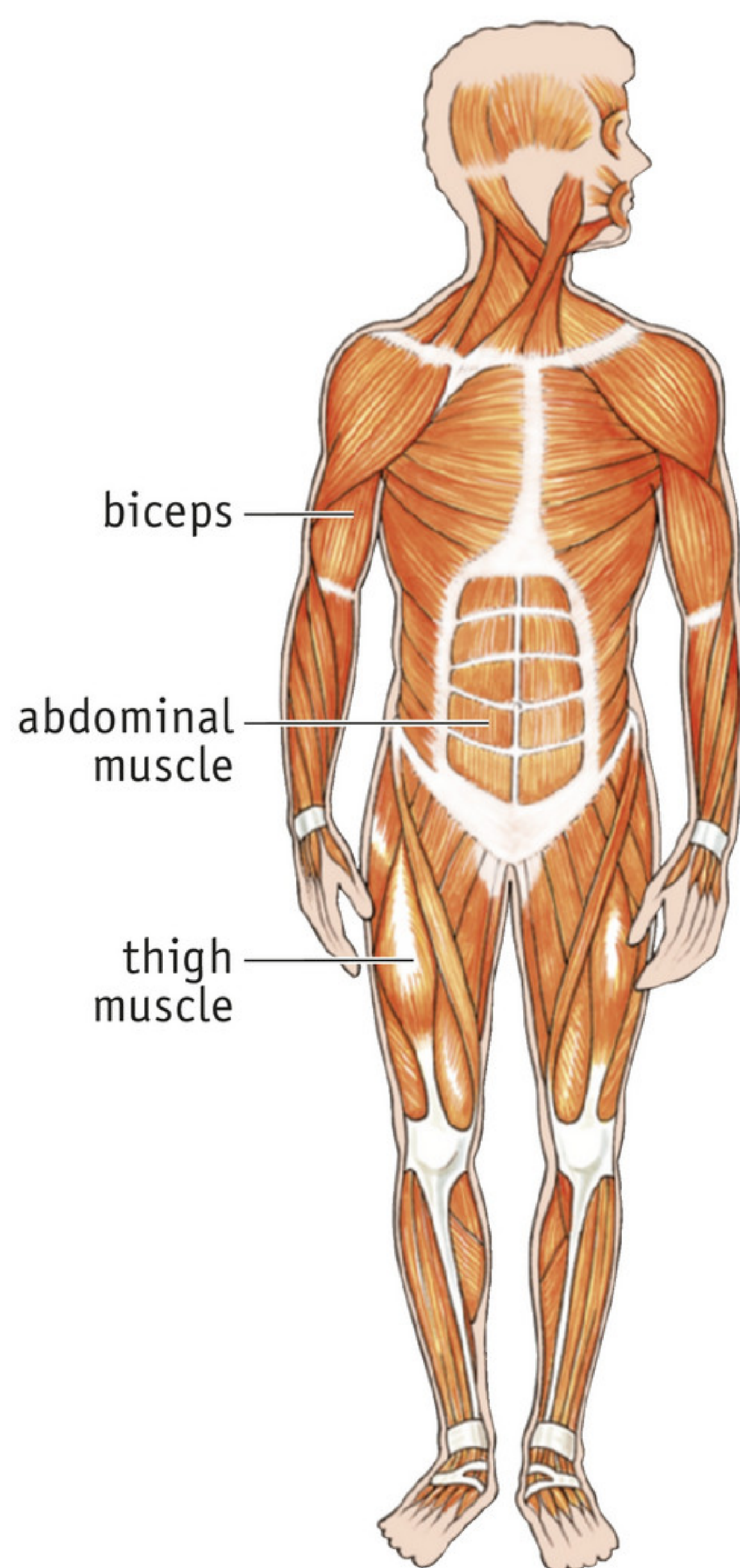
1 respiratory system



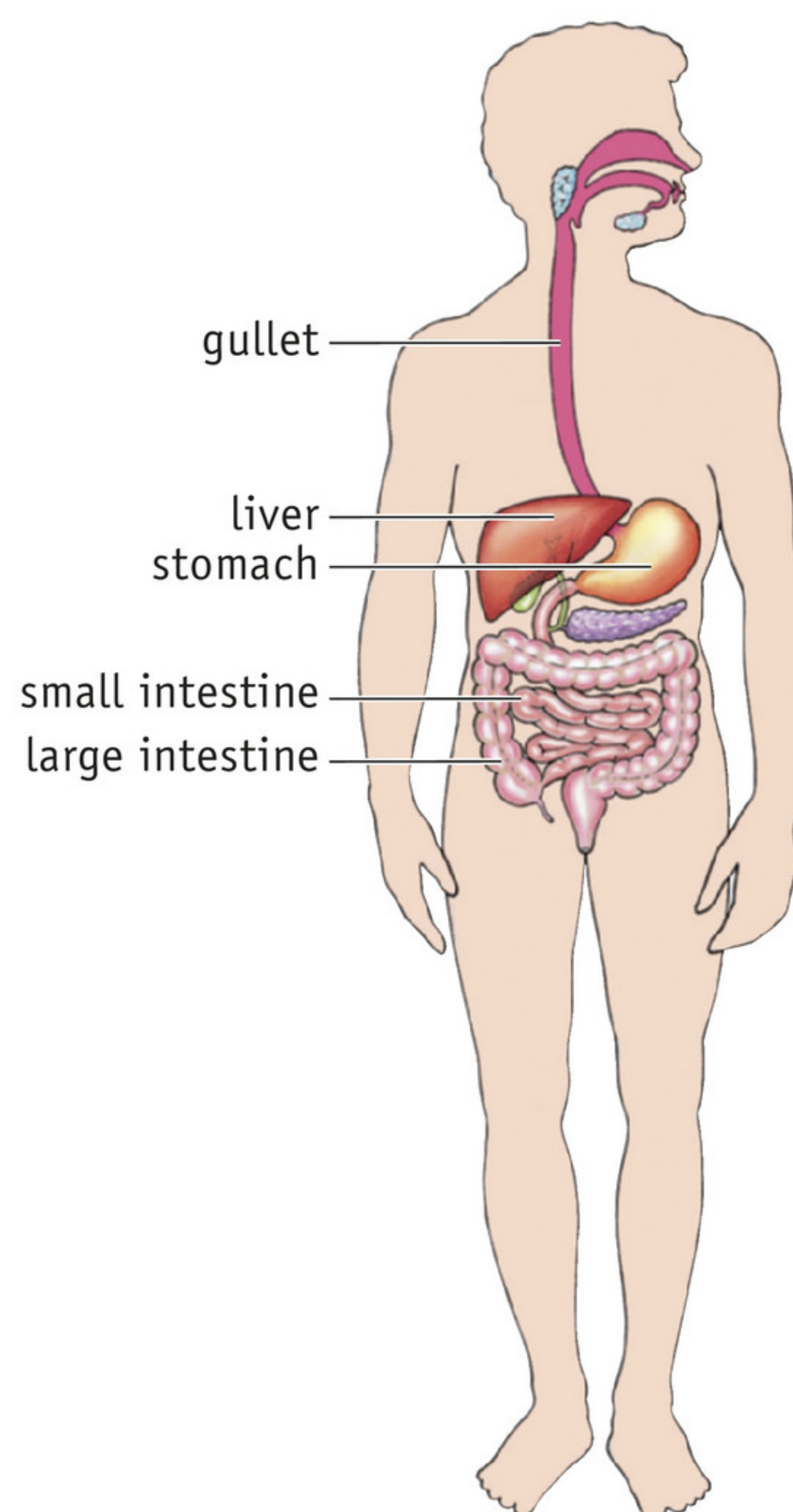
2 skeletal system



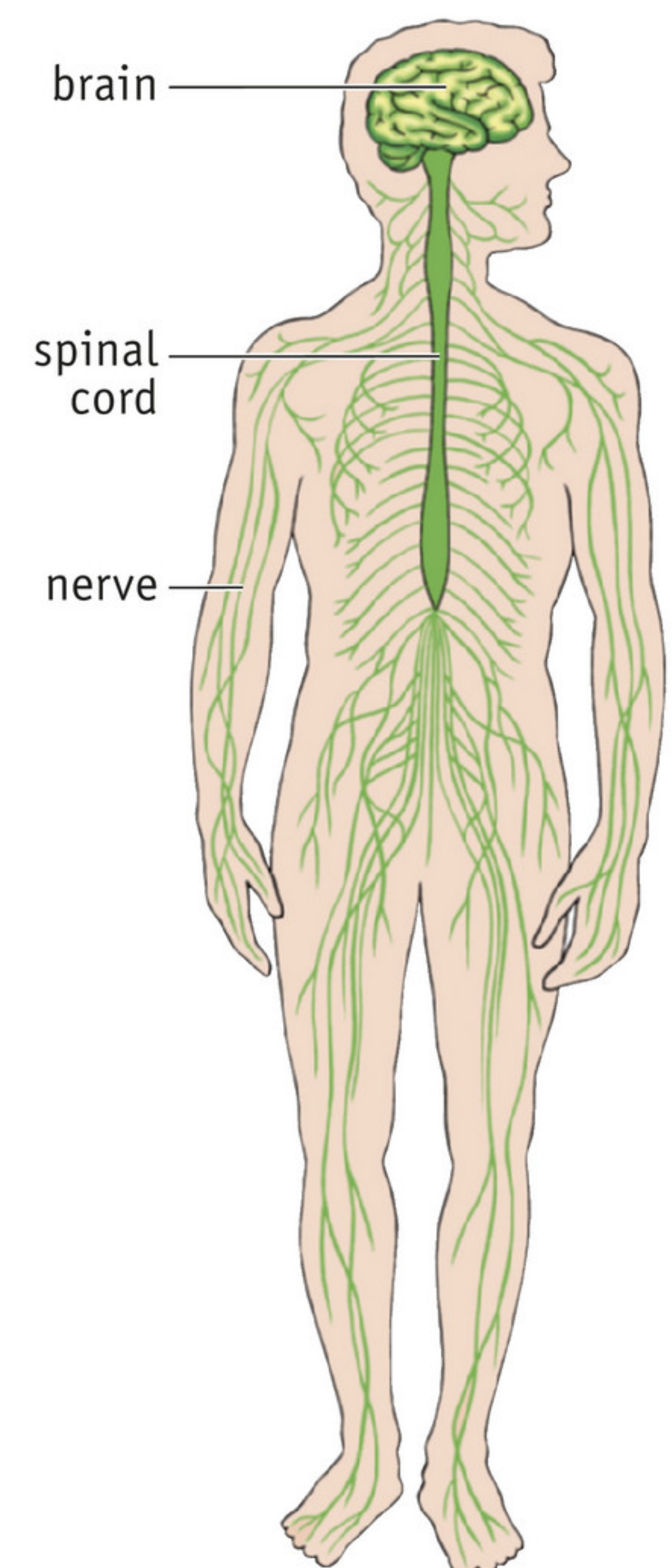
3 circulatory system



4 muscular system

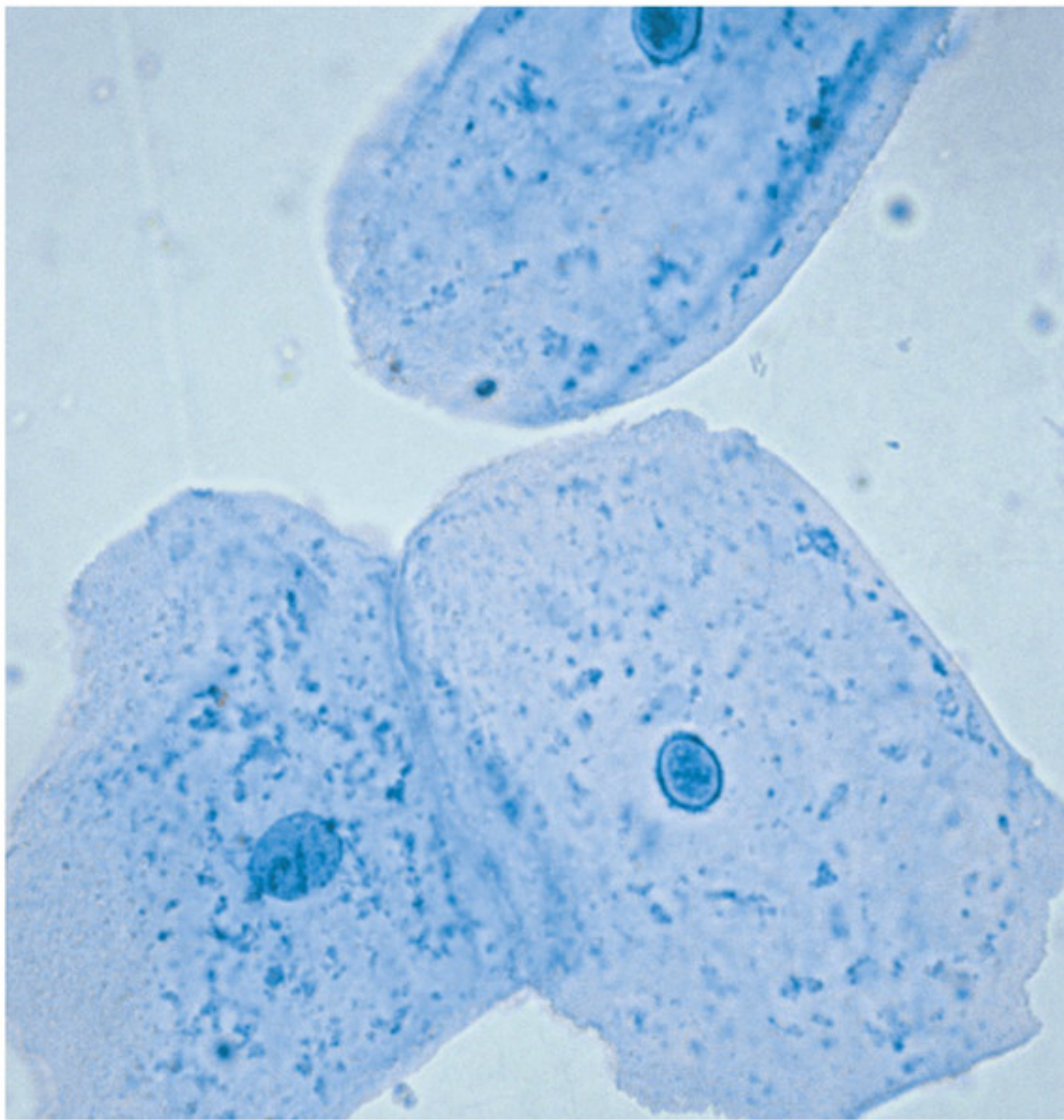


5 digestive system

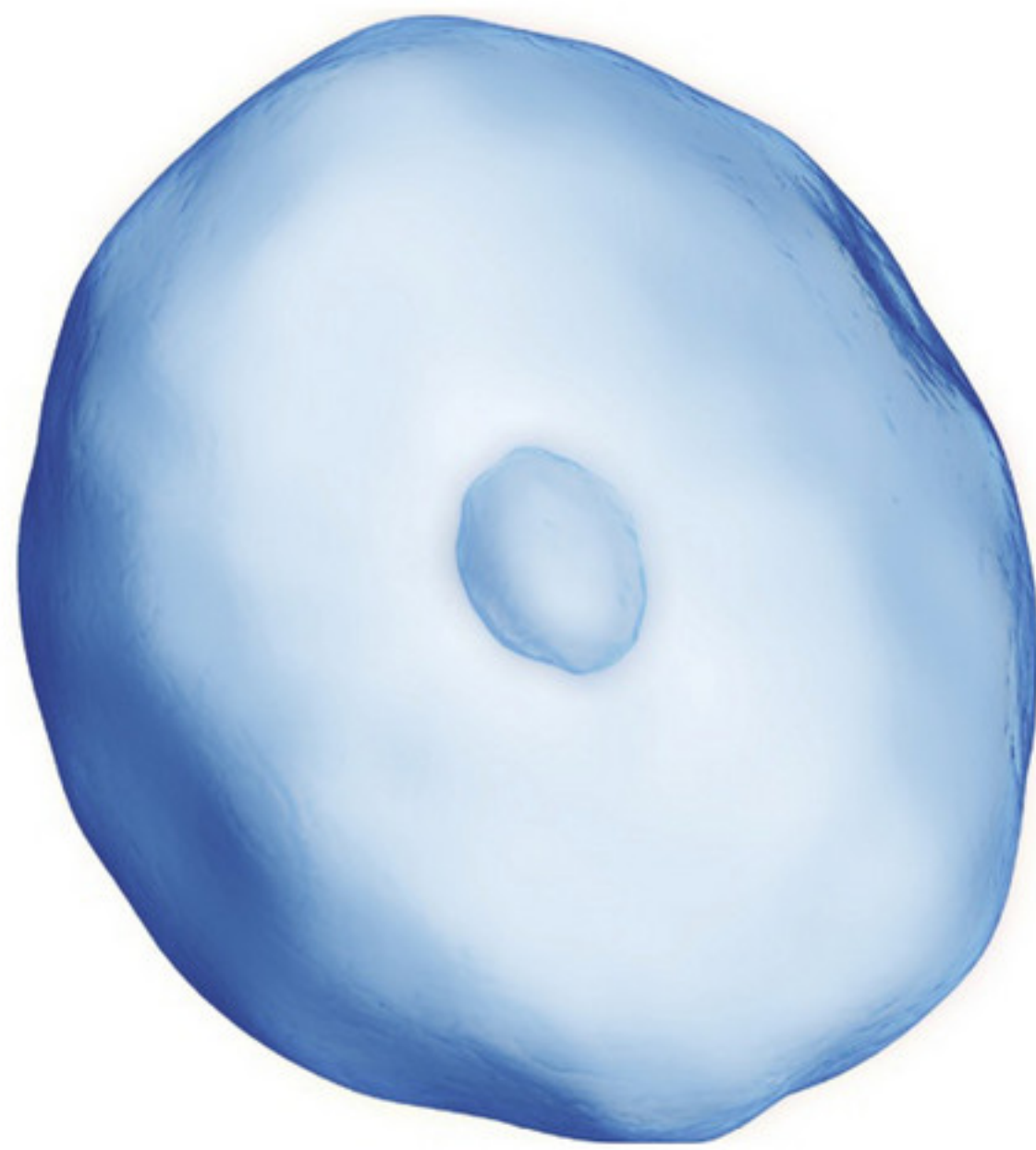


6 nervous system

▼ Fig. 4 Cells.



1 cells as they appear through a microscope



2 cells are three-dimensional

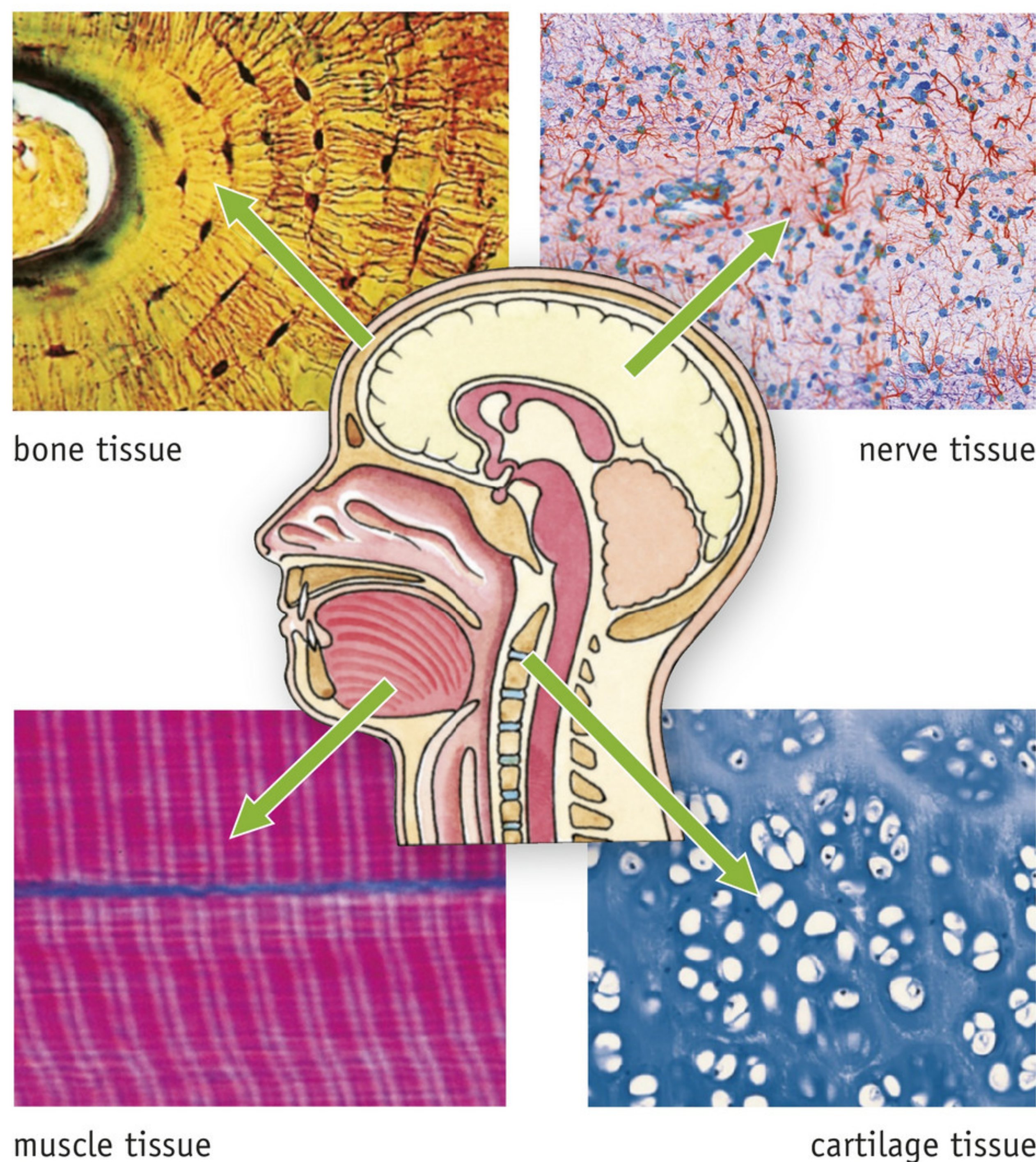
CELLS

Organisms consist of one or more **cells**. Cells are really small and you can only see them with the help of an instrument such as a microscope. When you look at cells through a microscope they seem flat, but they are actually three-dimensional (see figure 4). Cells come in all kinds of shapes. Some cells look like a little ball, others are cube-shaped or have bits sticking out that make them look like a star. The shape of a cell is related to its function.

TISSUES

Cells of the same type are often found clustered together in organs (see figure 5). Groups of cells with the same shape and function are called **tissues**. The bones in your body are made up mostly of bone cells. Together, the bone cells form bone tissue. The brain contains nerve tissue and the muscles contain muscle tissue. The cartilage tissue in your ear is what gives it its shape.

▼ Fig. 5 Tissues.

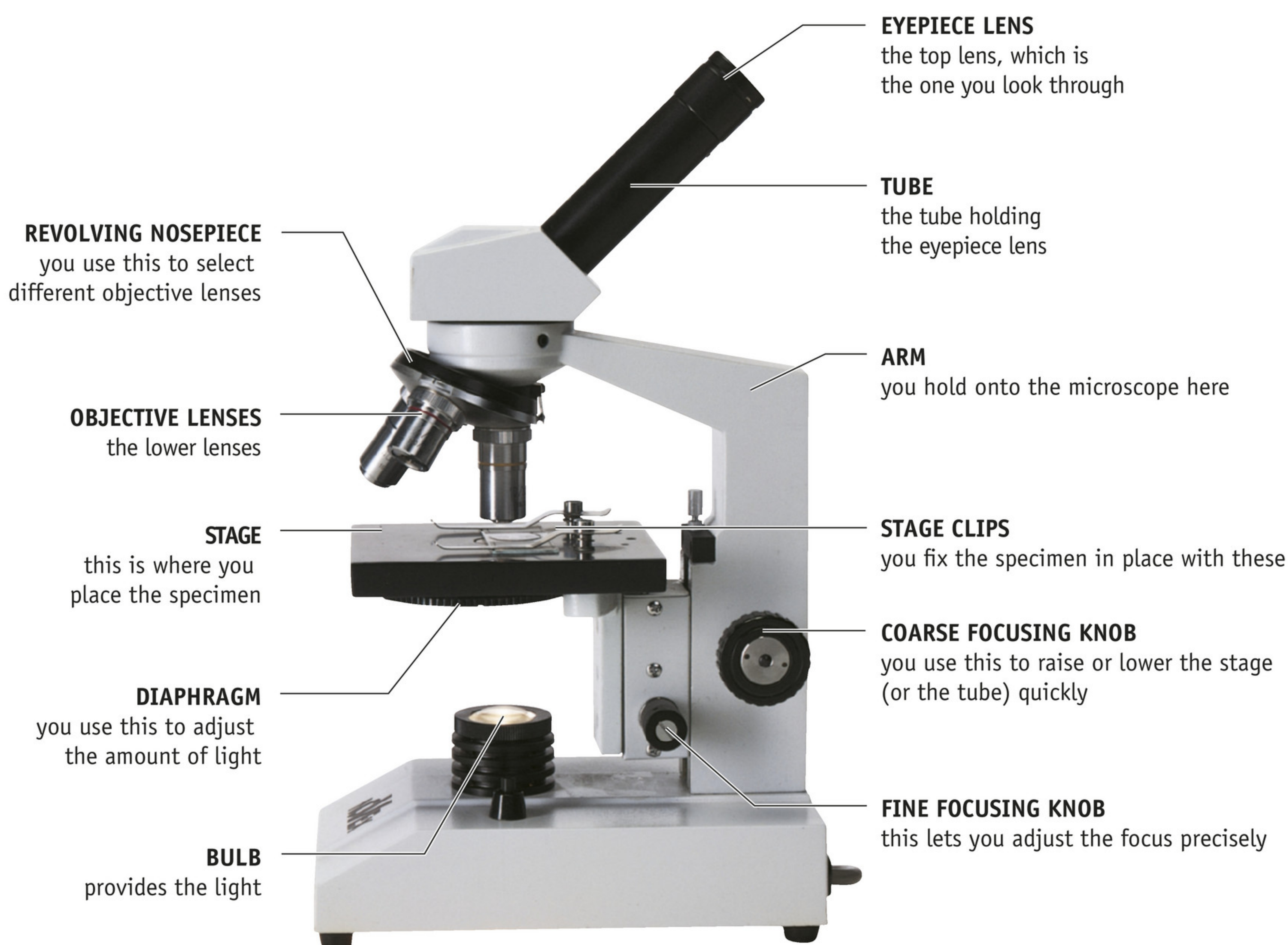


Many tissues have **extracellular material** between the cells. Extracellular material can take many different forms. Sometimes it can be a liquid, while in other cases it can be a substance produced by the tissue cells. Bone cells give off chalky substances that end up in the space between the cells. The bone cells stay in contact with one another through extensions. The extracellular material in cartilage is firm and flexible and the extracellular material in the nerve tissue in your brain is cerebrospinal fluid.

2 The microscope

You can use a microscope to look at cells and tissues. There are different kinds of microscopes. The most common are the light microscope and the electron microscope. Light microscopes let you magnify objects up to 1000 times, while an electron microscope lets you magnify them up to almost 1,000,000 times. At school, you use a **light microscope** to look at cells, for instance. The microscopes at school have a magnification of up to approximately 600 $\times$.

▼ **Fig. 6** A microscope.



A microscope consists of a lot of parts (see figure 6). You hold on to a microscope by the **arm**. You look through the top lens, the **eyepiece lens**. Most microscopes have two eyepiece lenses, one that magnifies 5 times and one that magnifies 10 times. You usually use the eyepiece lens that magnifies 10 times. The eyepiece lens fits loosely inside the tube so you should never hold the microscope upside down, or else the eyepiece lens will fall out!

At the bottom of the tube is the **revolving nosepiece**. This is a rotatable disc to which the **objective lenses** are attached. There are usually three objective lenses attached to the revolving nosepiece. The magnification is shown on the objective lens.

You can get different magnifications by using different combinations of eyepiece lens and objective lens. You calculate the total magnification by multiplying the eyepiece lens magnification by that of the objective lens. So if you use an eyepiece lens that magnifies everything 5 times and an objective lens that magnifies everything 10 times, the total magnification is 50 times.

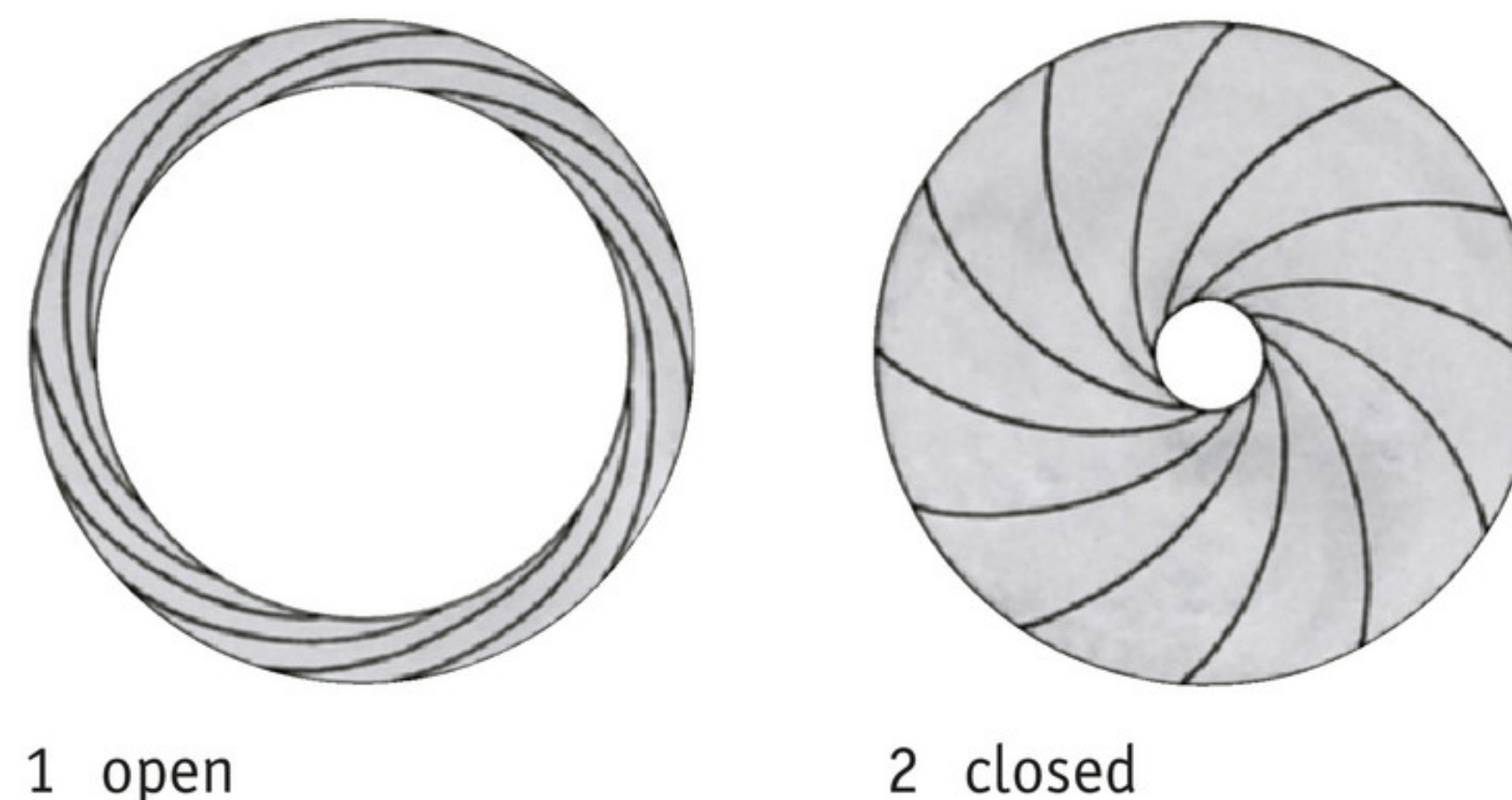
Most school microscopes have two knobs on the arm, a coarse focusing knob and a fine focusing knob. Turning these knobs changes the distance between the **stage** and the objective lenses. In some microscopes the stage moves up or down, whereas in other microscopes it is the tube and the objective lenses that move.

The object that you want to examine with the microscope is called the **specimen**. You put the specimen on the stage, in the middle above the opening. You clamp the specimen in place with the **stage clips**. There is a **diaphragm** under the stage. You use this to adjust the amount of light (see figure 7).

Some microscopes have a **rack stop** (a small screw). The rack stop prevents the objective lens from touching the specimen. You must not turn the rack stop screw yourself.

WB EXERCISES 7 AND 8, PAGE 72

▼ **Fig. 7** A diaphragm.



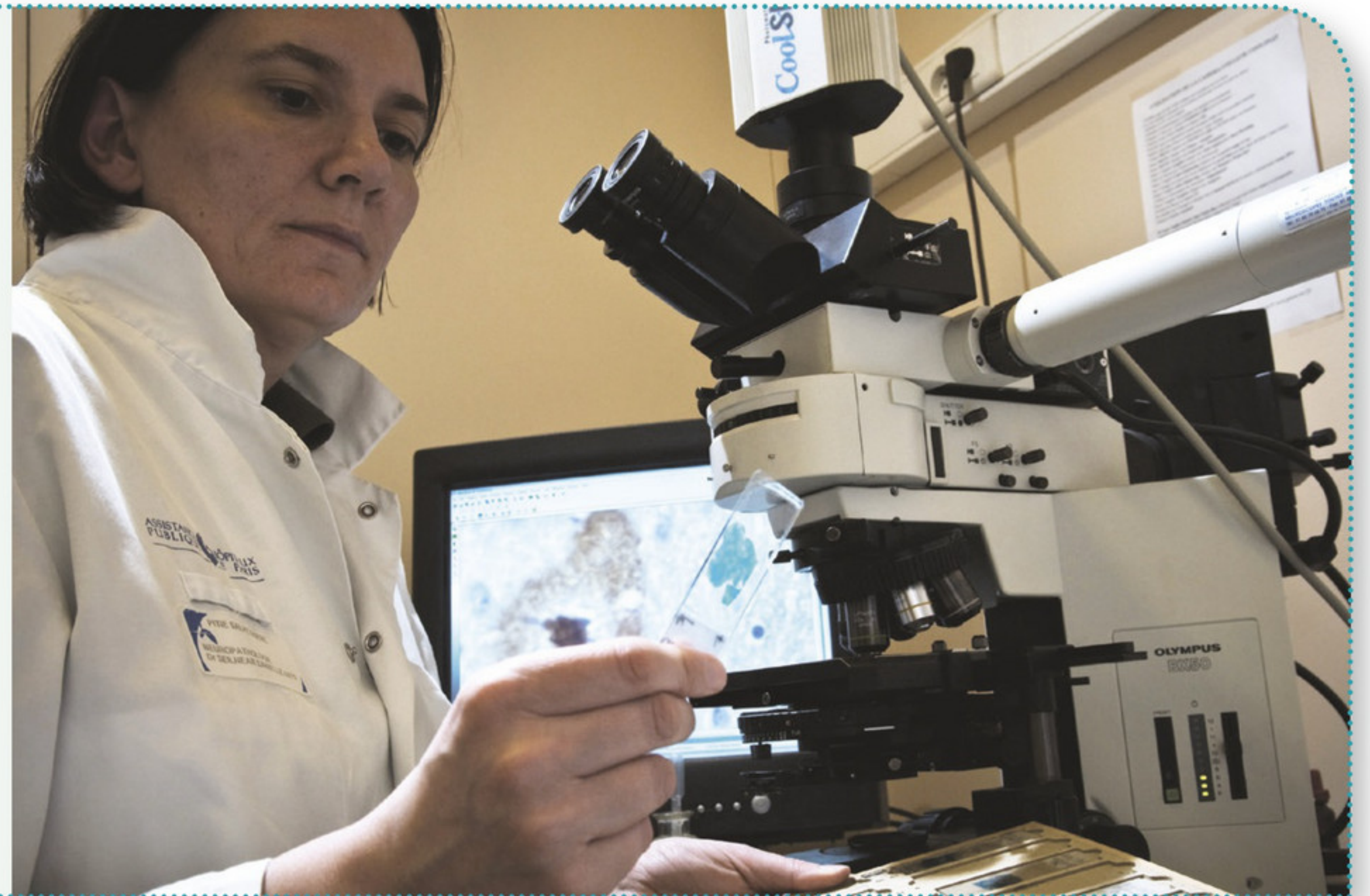
3 Microscopy

An operation in which someone is given a donor organ or donor tissue is called a **transplant**. Transplants don't always go well. The body might reject a donor organ, which means that the cells of the new organ then die off. A doctor can have tests done on a few cells or a piece of tissue from the organ to test for rejection. A specimen is prepared from the cells or tissue in a laboratory. A pathologist examines the specimen through a microscope (see figure 8).

▼ Fig. 8

A pathologist

Eva van de Groot: “A pathologist is a specialist doctor who examines cells and tissues to try and find out what caused an illness or death. A microscope is a really important instrument for such examinations.”



A specimen is prepared using a thick piece of glass, the **microscope slide**, and a thin piece of glass, the **cover slip**. The object you want to examine is placed between the slide and the cover slip. That object could be cells or a piece of tissue. The object is usually in a liquid. If you are using a light microscope, light must shine through the object and so the object has to be very thin. Many kinds of tissues and cells can be bought as ready-made specimens (see figure 9).

▼ Fig. 9 A specimen.



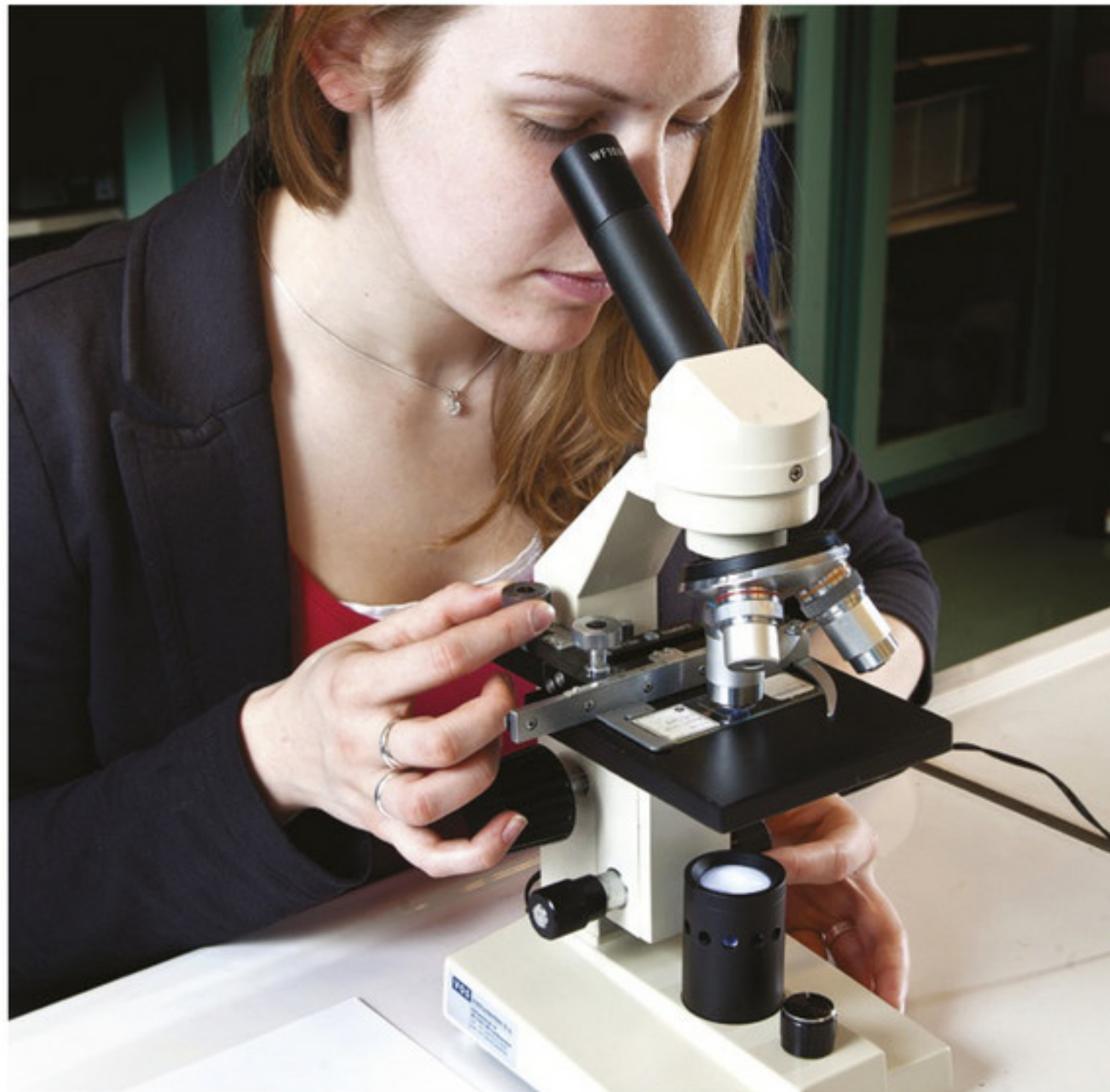
When you look at a specimen through a microscope, you should always start by focusing at the lowest magnification. That will make it easy to find the specimen on the slide. It also reduces the chance of you touching the specimen with an objective lens. Figures 10 and 11 show how you should focus the microscope. Figure 12 tells you what to do if you can't see anything.

WB EXERCISES 9 TO 14, PAGE 73

▼ Fig. 10

TECHNIQUES IN BIOLOGY		
FOCUSING AT THE LOWEST MAGNIFICATION		
		
1 Turn the coarse focus to raise the tube all the way up (or lower the stage all the way down). Turn the nosepiece until the smallest objective lens is above the stage.	2 Place the specimen between the clips. Make sure that what you want to look at is in the middle above the opening in the stage.	3 Look at the microscope from the side. Turn the coarse focus to lower the tube all the way down (or raise the stage all the way up). Make sure that the specimen does not touch the objective lens.
		
4 Look through the eyepiece lens. Turn the coarse focus slowly to raise the tube (or lower the stage). Stop when the image is reasonably well focused.	5 Use the fine focus to focus the image precisely.	

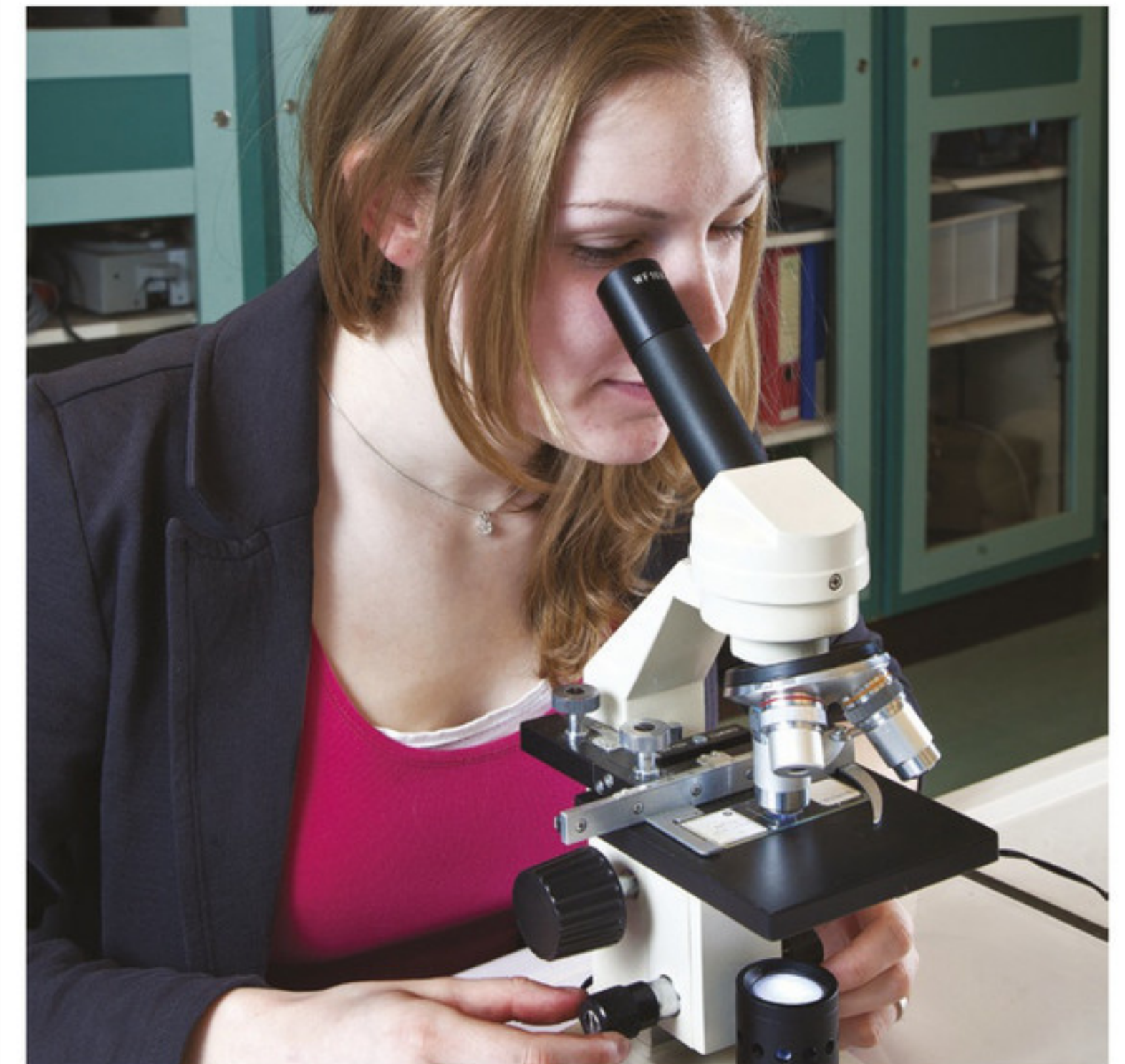
▼ Fig. 11

TECHNIQUES IN BIOLOGY**USING A HIGHER MAGNIFICATION**

- 1 You have already focused the image at a smaller magnification. Look through the eyepiece lens. Shift the specimen so that what you want to magnify further is in the middle of the image.



- 2 Look at the microscope from the side. Rotate the objective lenses to get the lens that is one size bigger. Do not turn the coarse focusing knob.



- 3 Use the fine focusing knob to focus the image precisely.

▼ Fig. 12

IF YOU DON'T SEE ANYTHING

If you don't see an image, that might be for one of the following reasons:

- 1 You have not turned the revolving nosepiece properly, so that the objective lens is not precisely above the specimen. In most microscopes, the revolving nosepiece clicks into place.
- 2 The specimen is not placed properly above the opening in the stage.
- 3 You are using too high a magnification.
- 4 The diaphragm is not letting any light through.
- 5 The bulb is not switched on.

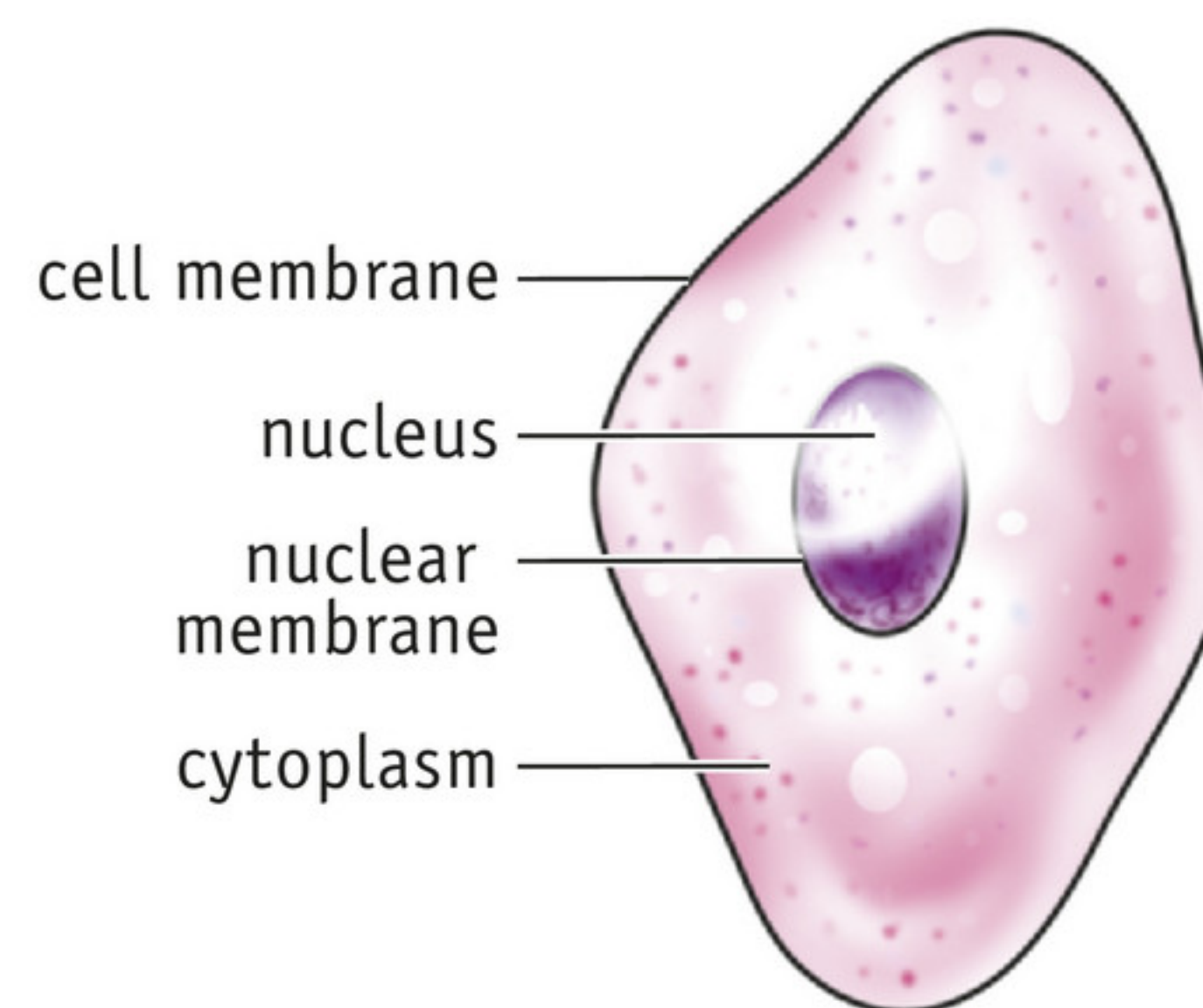
Check the above before you ask for help.



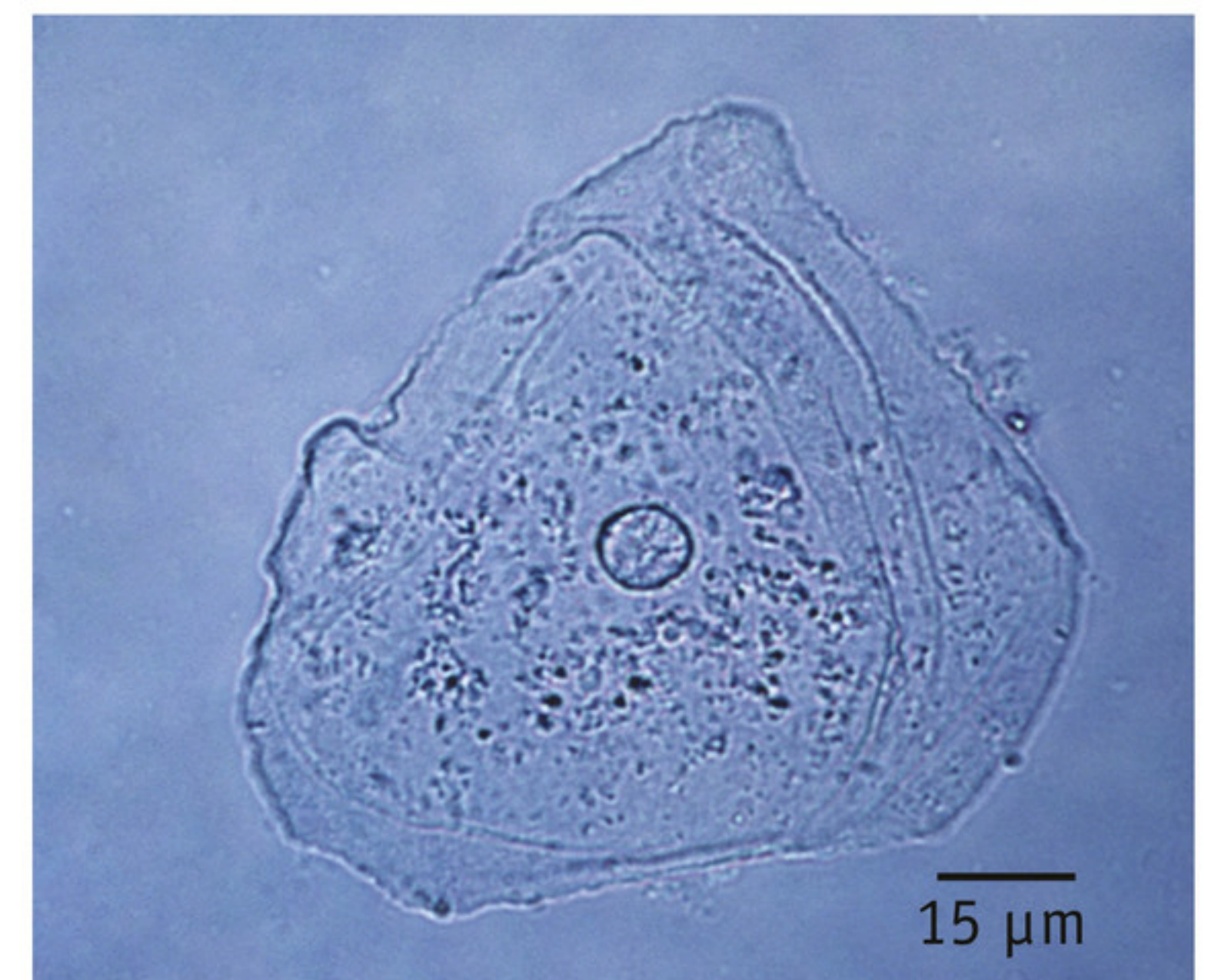
4 Cells

Cells can differ a great deal in their shapes, but there are similarities in their structure. All cells contain cytoplasm (cell plasma) surrounded by a membrane. The **cytoplasm** consists of water with dissolved substances, in which particles float. The **cell membrane** is a thin layer that separates the contents of the cell from its surroundings. The membrane consists mainly of fats and proteins. The proteins play a role in the uptake and secretion of substances. In plants and animals, the cytoplasm contains a **nucleus**. The nucleus consists of nuclear plasma and is also surrounded by a membrane: the **nuclear membrane** (see figure 13). The nucleus is responsible for the cell's self-regulation and self-organisation. It is the cell's control centre.

▼ **Fig. 13** A cell.



1 drawing of a cell



2 photo of a cell (cheek lining cell, 600× magnification)

PREPARING A SLIDE

You have already looked at a ready-made specimen through a microscope. Now you will learn how to prepare your own specimens. You use preparation materials when preparing a specimen. Figure 14 shows the materials you will often need.

WB EXERCISE 15, PAGE 78

▼ **Fig. 14** Materials for preparing a slide.



1 slide



2 cover slip



3 tissues



4 pipette



5 blade



6 tweezers



7 mounted needle



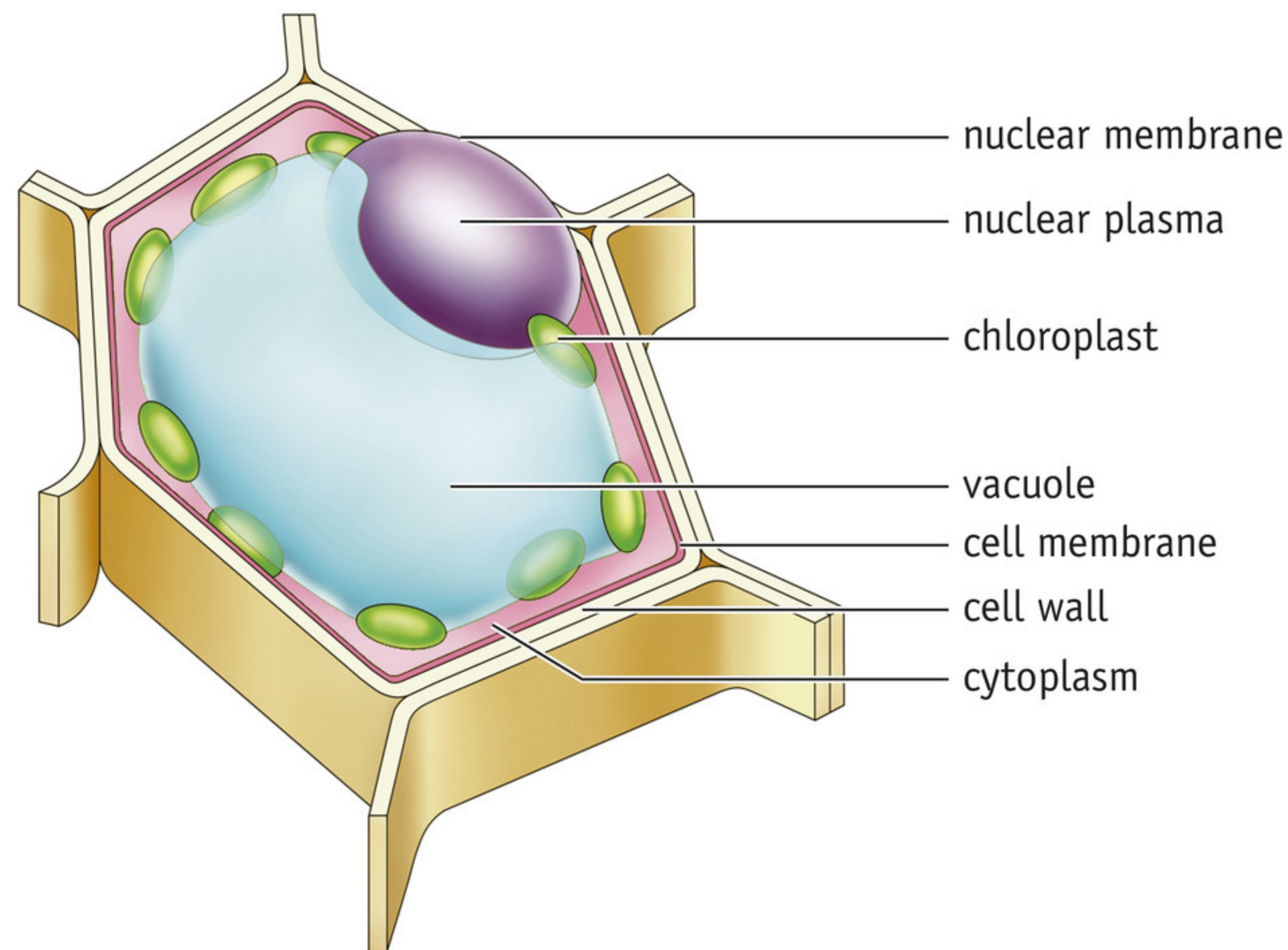
8 filter paper

PLANT CELLS

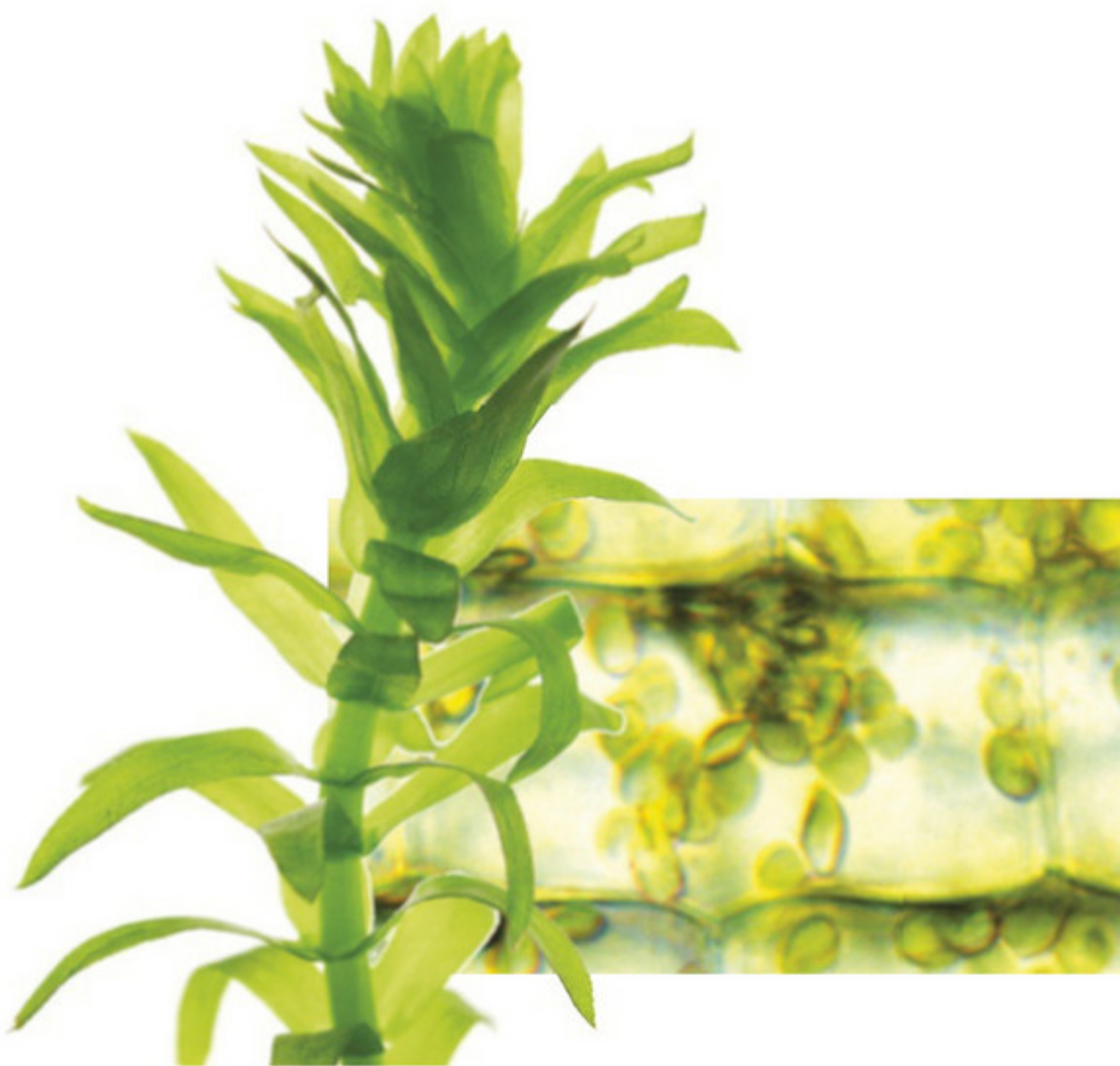
Plant cells differ from animal cells. Most plant cells have a large **vacuole** in the middle of the cell. A vacuole is a kind of ‘sac’ filled with sap. The cell sap consists of water with dissolved substances.

Plant cells create a strong layer to surround the cell, called the **cell wall**. The cell wall is extracellular material (see figure 15). Cell walls make everything firm.

▼ **Fig. 15** A plant cell (schematic).



▼ **Fig. 16** Chloroplasts in the cells of waterweed.



You call the parts of a cell that have their own function **cell organelles**. You have already met a number of cell organelles, such as the nucleus and the vacuole. Cells contain many other cell organelles as well. **Plastids** (granules), for example, can be found in the cytoplasm of plant cells. There are different kinds of plastids.

Chloroplasts are found in plant leaves (see figure 16). The chloroplasts make the plant look green. Photosynthesis takes place in the chloroplasts. You learned what happens in photosynthesis in Unit 2 (Plants).

Chromoplasts are found in the cells of flowers and fruits that are yellow, orange or red (see figure 17). Chromoplasts give the flowers and fruits their striking colour.

Amyloplasts are starch grains that are found in the cells of potatoes, for instance (see figure 18). Amyloplasts are colourless. Amyloplasts store starch. Plastids can change from one type to another. For example, when a tomato ripens, its colour changes from green to red as the green chloroplasts change into red chromoplasts.

▼ **Fig. 17** Chromoplasts in the cells of a tomato.



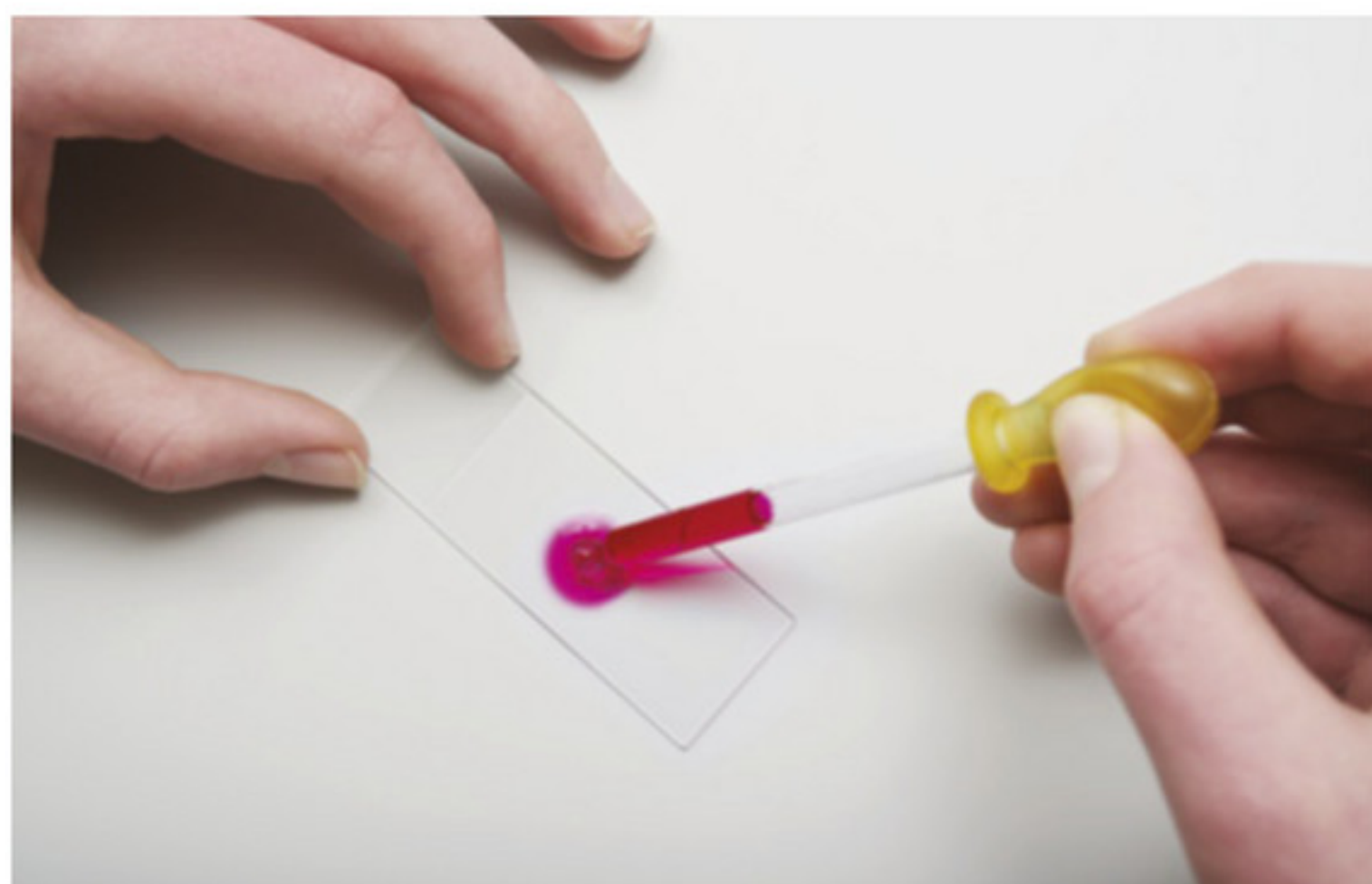
▼ **Fig. 18** Amyloplasts in the cells of a potato.



In exercise 16 you will be preparing and examining a specimen of the skin of an onion. Figure 19 shows how to prepare a specimen from the skin of an onion. An onion is made up of food storage leaves. You can remove the innermost layer of a food storage leaf as a thin transparent skin (see figure 19.2). Figure 20 shows you what a specimen should look like.

WB EXERCISES 16 TO 20, PAGE 79

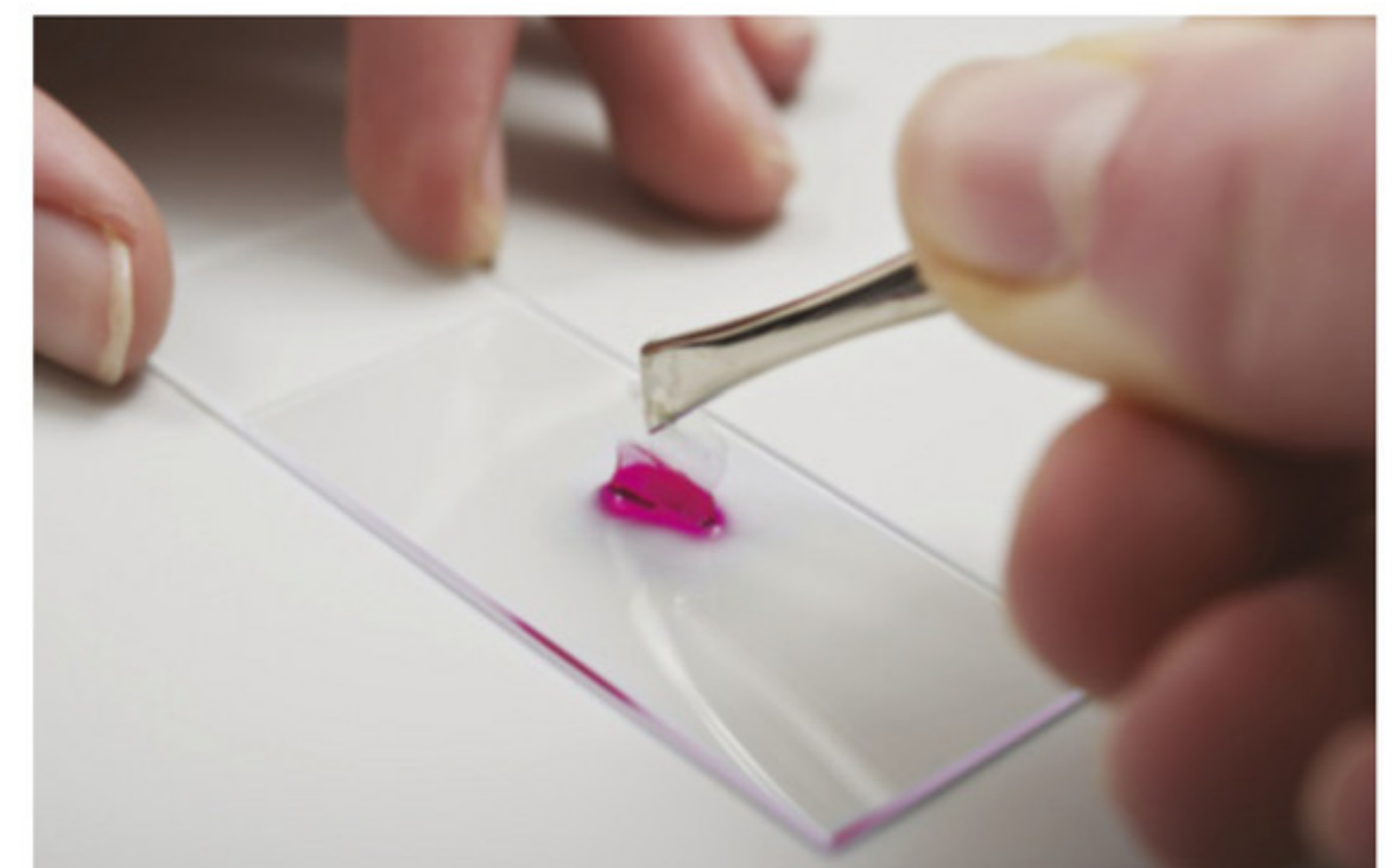
▼ **Fig. 19** Preparing a specimen from the skin of an onion.



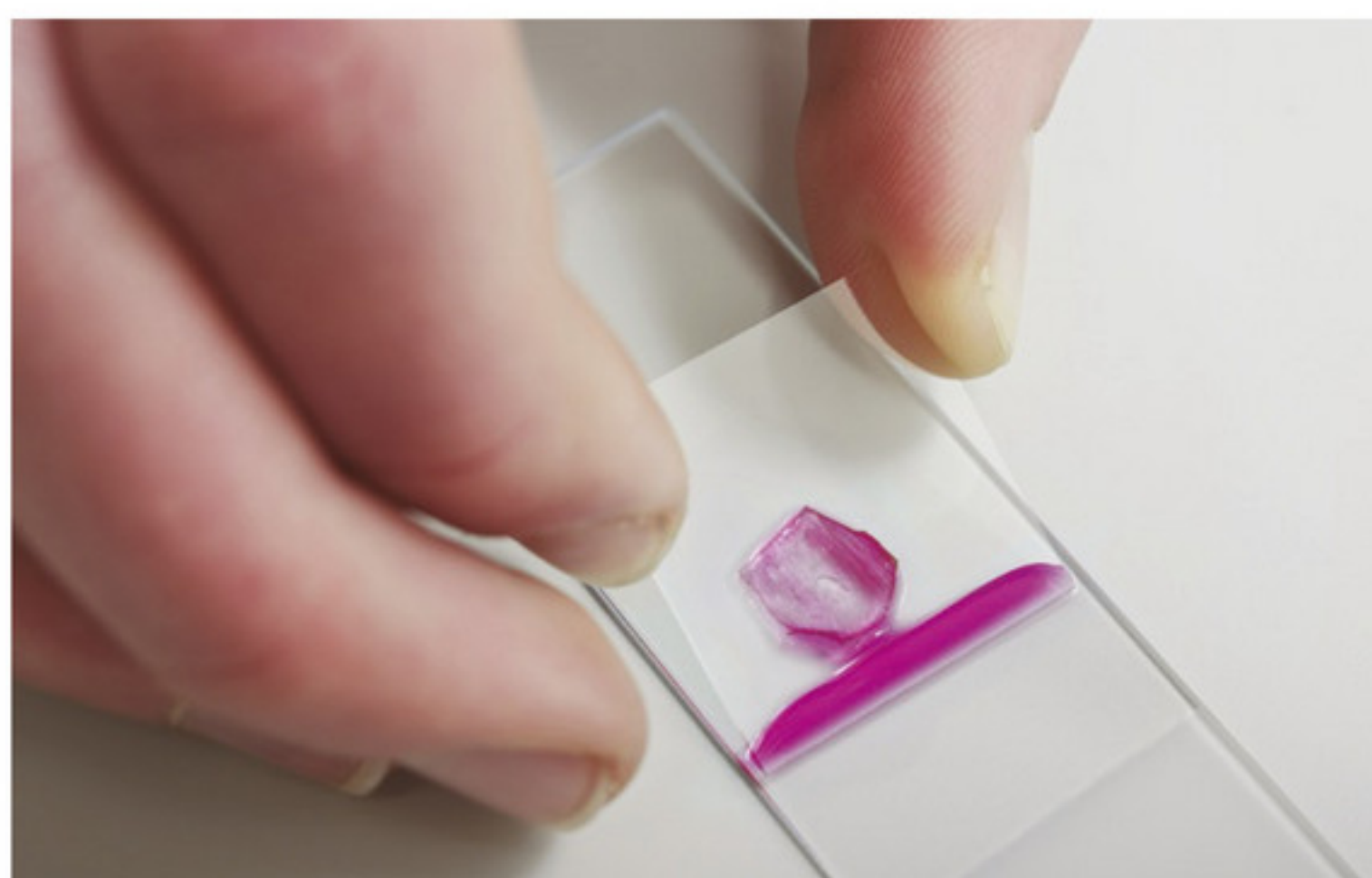
1 Take a slide and squeeze a drop of the dye solution onto it.



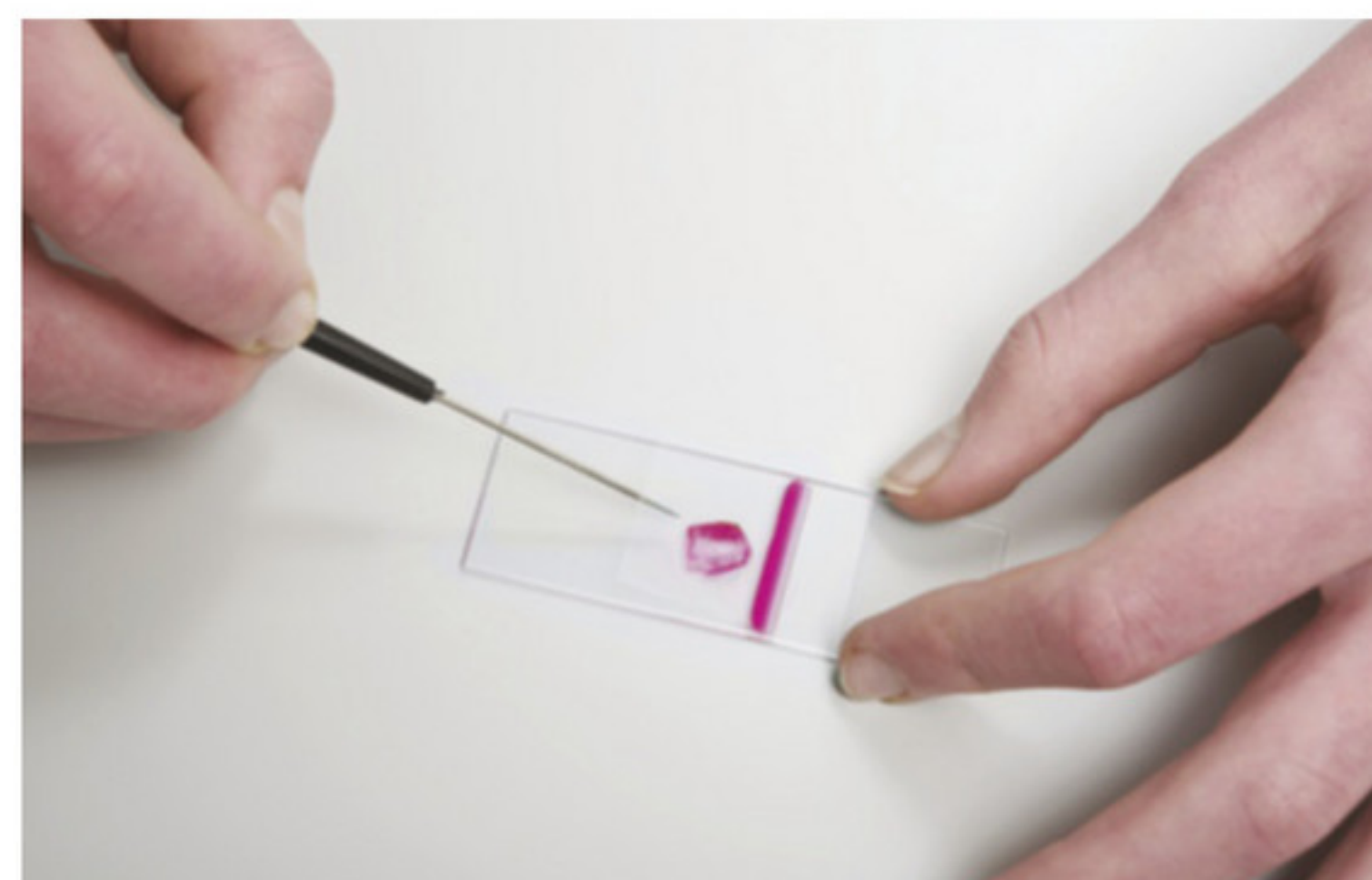
2 Use tweezers to pull off a layer of skin from the inside of the food storage leaf of an onion. Cut off a piece of the skin with the blade. You only need a piece 1 cm long.



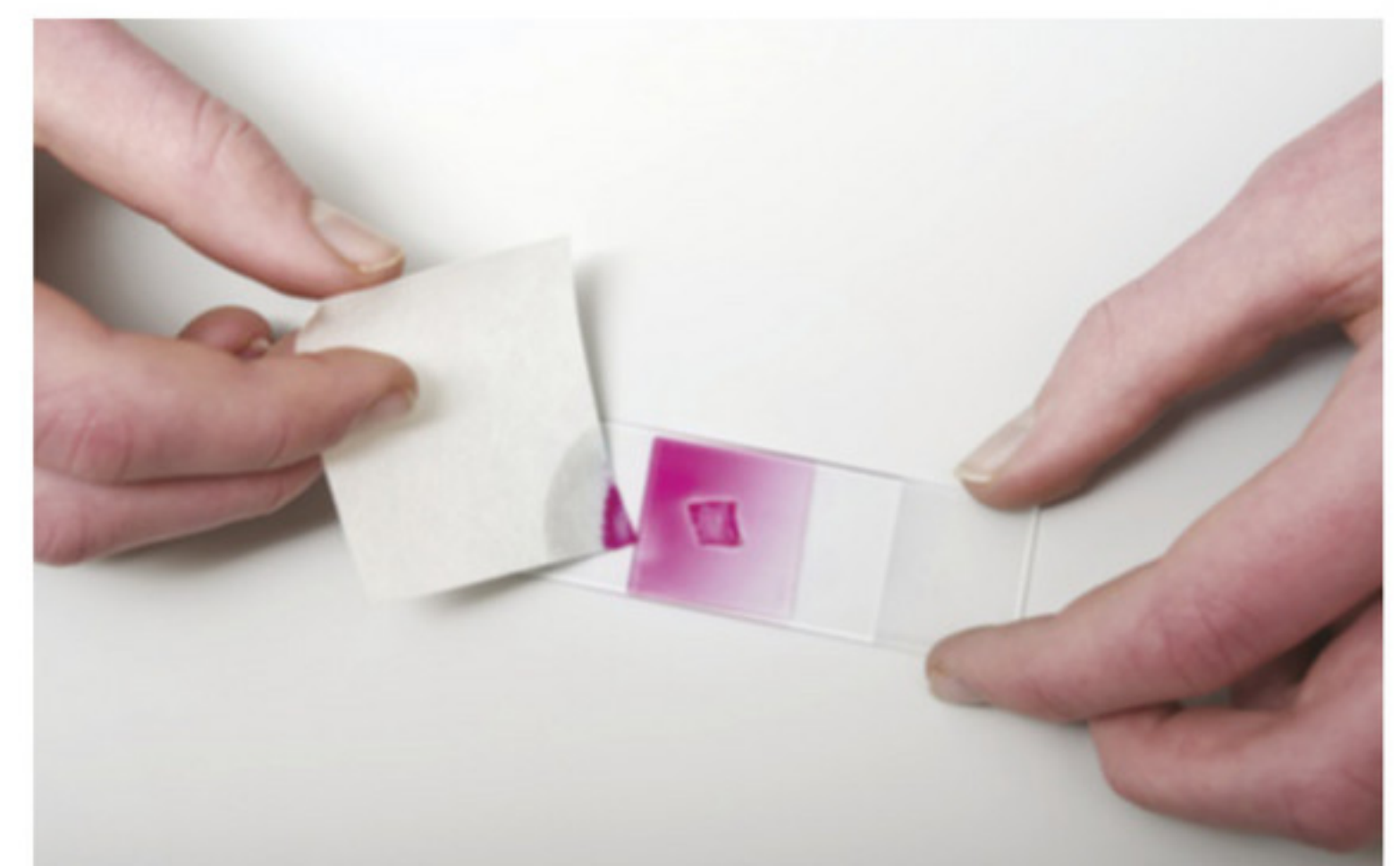
3 Place the piece of skin in the drop of dye solution. Make sure that the skin is not folded double.



4 Slide a cover slip against the drop of dye solution, keeping it tilted at an angle.

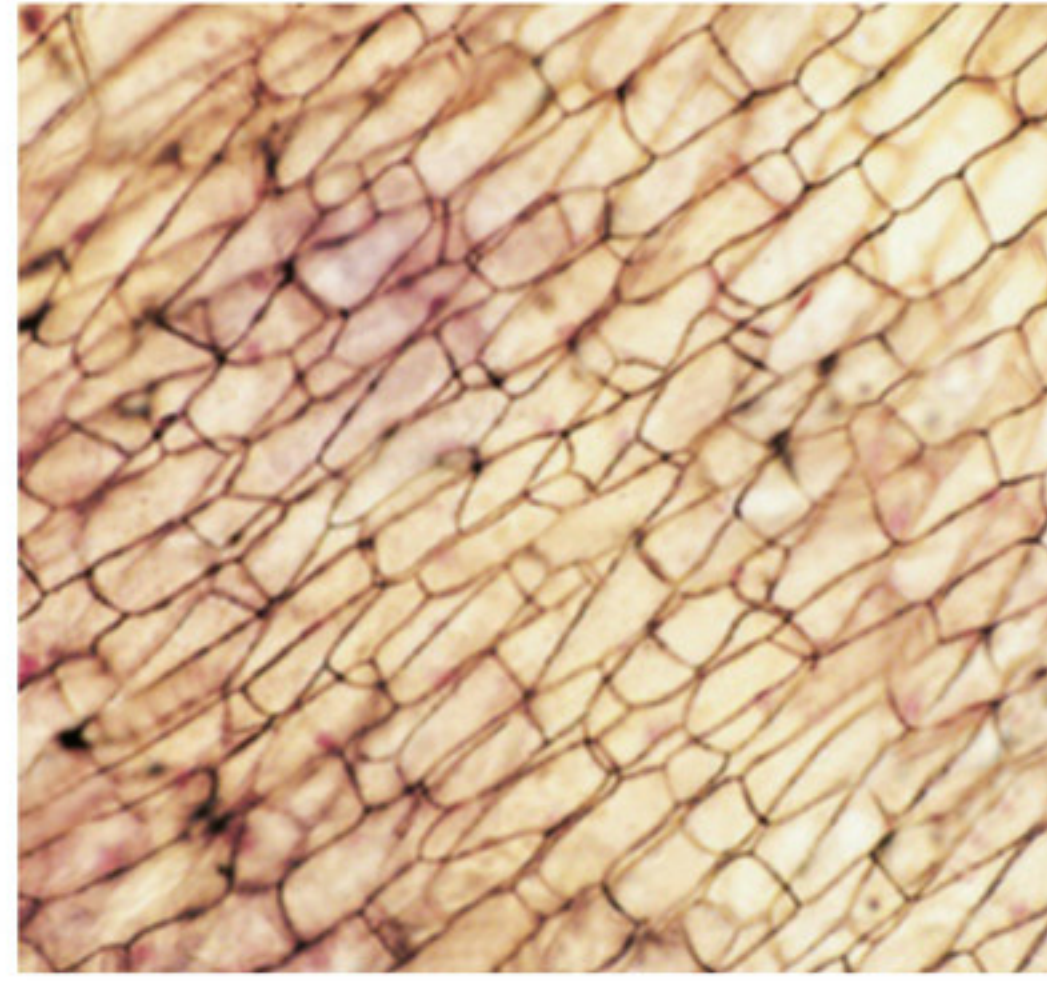


5 Lower the cover slip slowly onto the slide using a mounted needle. There must not be any air bubbles in the specimen.

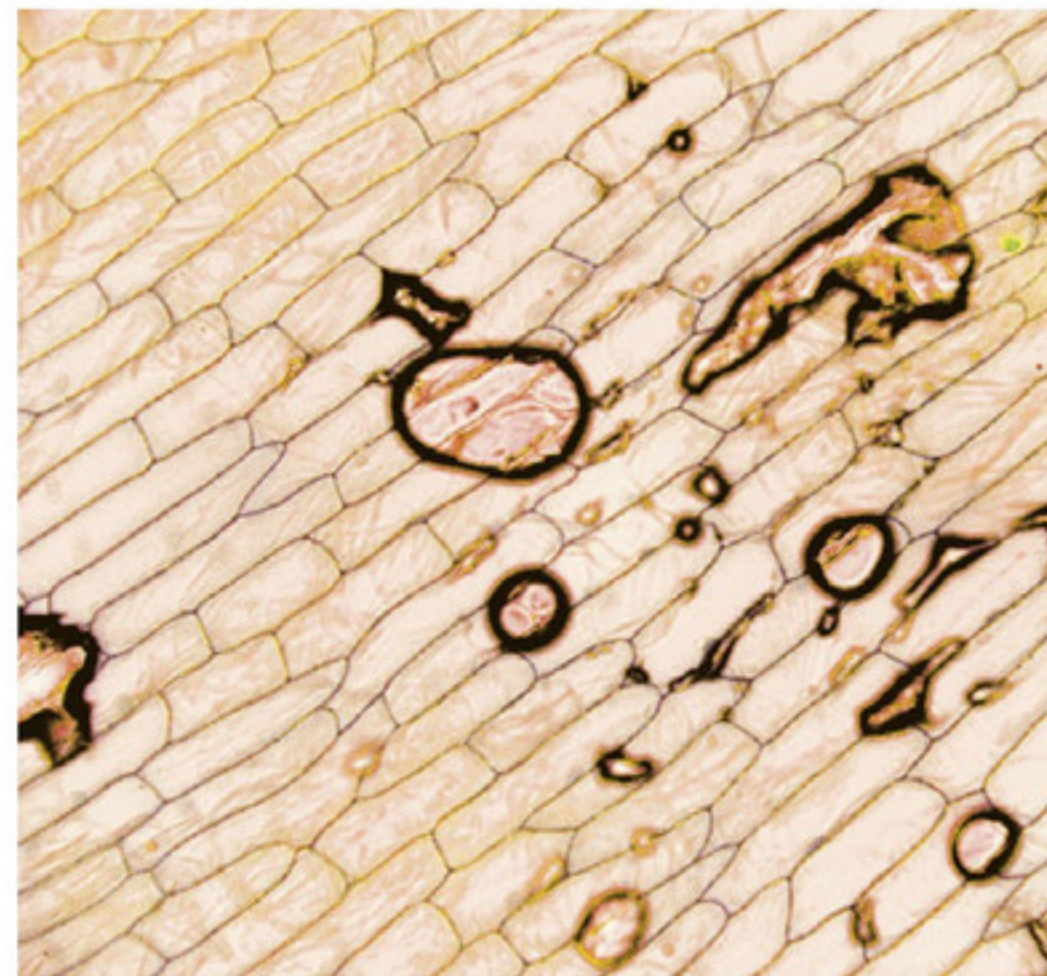


6 Remove excess dye solution with filter paper. Make sure you do not soak up any of the solution from under the cover slip.

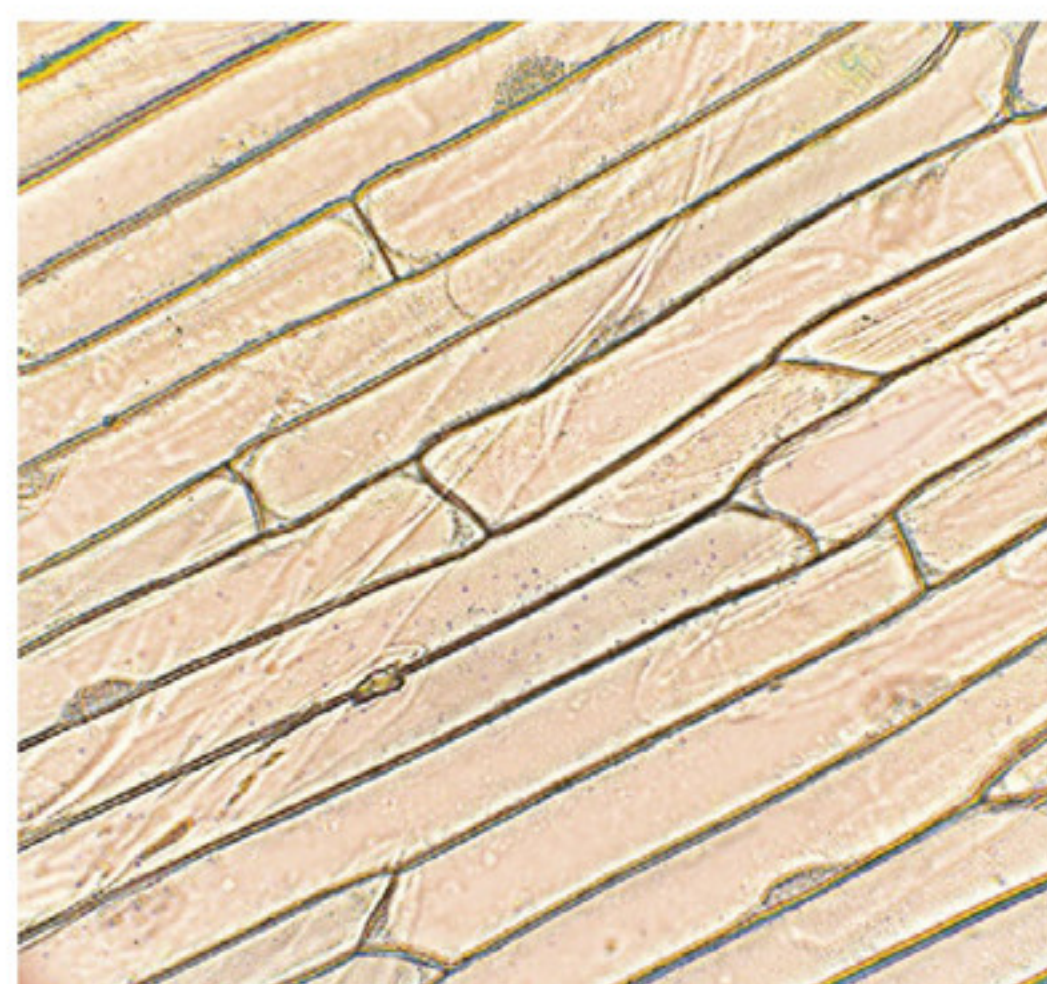
▼ Fig. 20

THIS IS WHAT A SPECIMEN SHOULD LOOK LIKE

- 1 If you see cell walls crossing each other, that means the skin is folded double. That may be because the piece of skin is too big. Find a spot where the skin is not folded double. If you can't, then take the specimen apart and make a new specimen with a smaller piece of skin.



- 2 If you see black circles, that means there are air bubbles in the specimen. That may be because you let the cover slip down onto the drop of dye solution too quickly. Lift up the cover slip at one edge using a mounted needle. Then let it down again, only very slowly this time.



- 3 Your specimen should look like this.

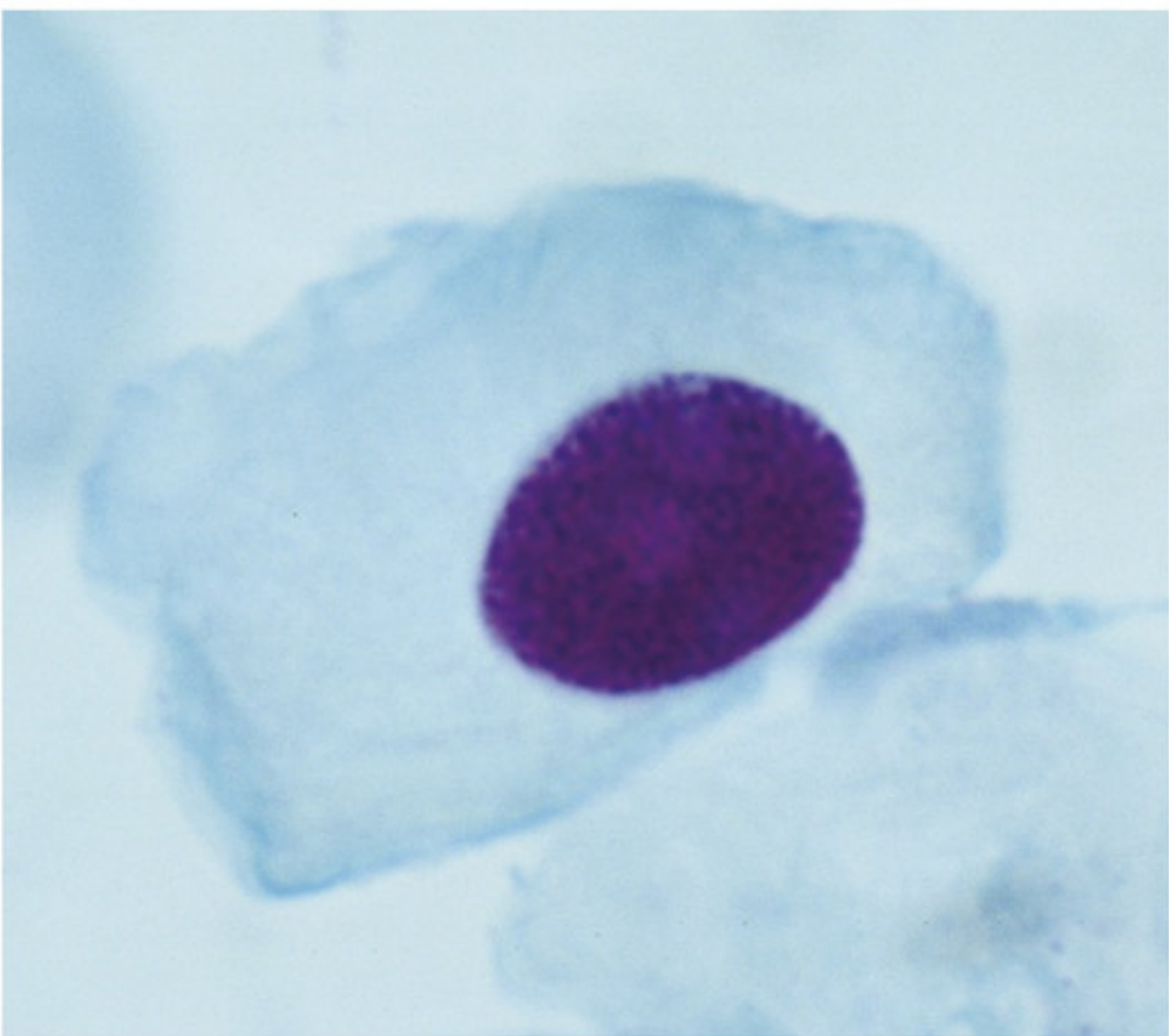
5 The nucleus

In Unit 1 What is biology? you learned that self-regulation, self-organisation, interaction, reproduction and evolution are important themes in biology. These topics also play an important role in cells. The nucleus is particularly relevant here.

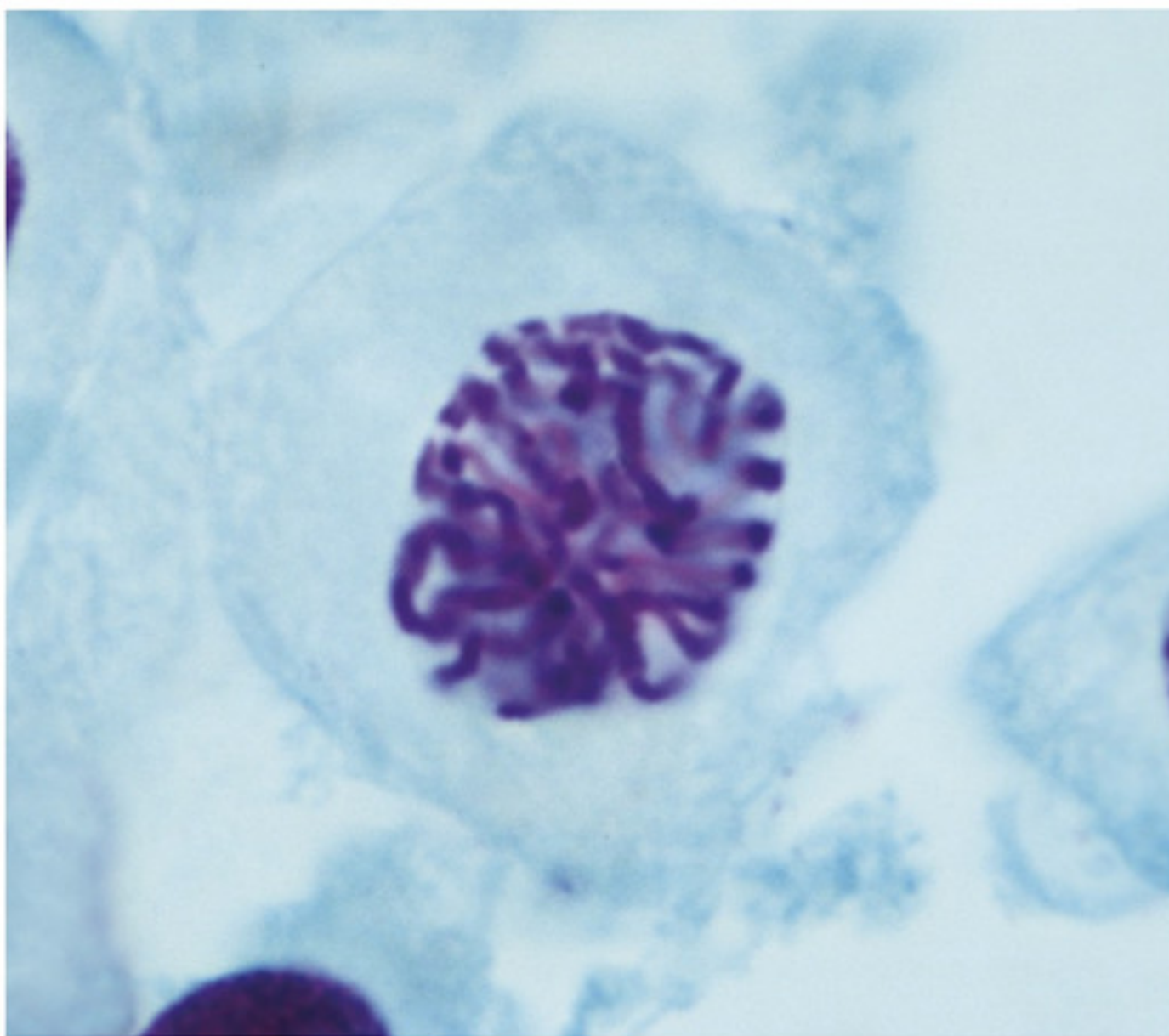
CHROMOSOMES

Every nucleus in your body contains **chromosomes**. Chromosomes are elongated thin ‘threads’. They are all tangled together in the nucleus. The chromosomes in a nucleus cannot be seen through a microscope, but the chromosomes do become visible when a cell divides (see figure 21).

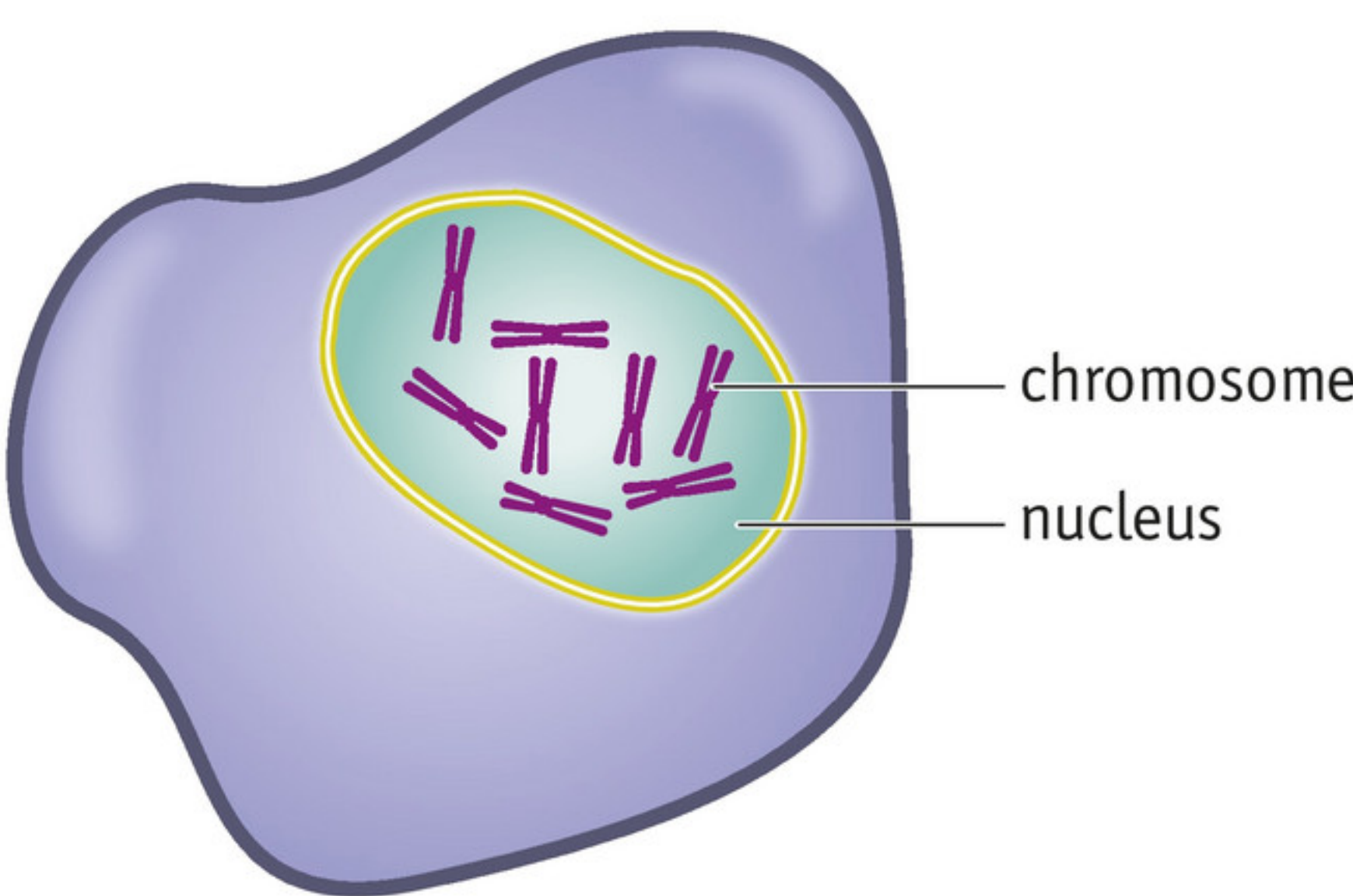
▼ **Fig. 21** The nucleus contains chromosomes.



1 a microscope photo of the nucleus in a cell that is not dividing



2 a microscope photo of a nucleus during cell division



3 schematic drawing

Every nucleus in your body contains 46 chromosomes. This applies to all cells that make up the body of a human. These cells are called **body cells**. Some examples of body cells are skin cells, liver cells and muscle cells. Each species of organism has a fixed number of chromosomes in the nucleus of all its body cells (see table 1).

▼ **Table 1** The number of chromosomes in selected organisms.

Name	Number of chromosomes per cell
Fly	12
Onion	16
Tomato	24
Cat	38
Human	46
Chimpanzee	48
Cow	60
Horse	64
Dog	78
Hedgehog	88

INHERITED CHARACTERISTICS

Chromosomes consist largely of **DNA**. The DNA contains the information for all your inherited characteristics.

The coloured part of your eyes is called the iris. Certain substances (pigments) in the iris cells determine the colour of the iris. The DNA contains the information about how to make these substances. Because you inherited this information from your parents, we call such properties **inherited characteristics**. Other examples of inherited characteristics are the shape of your face and being able to make substances that digest your food.

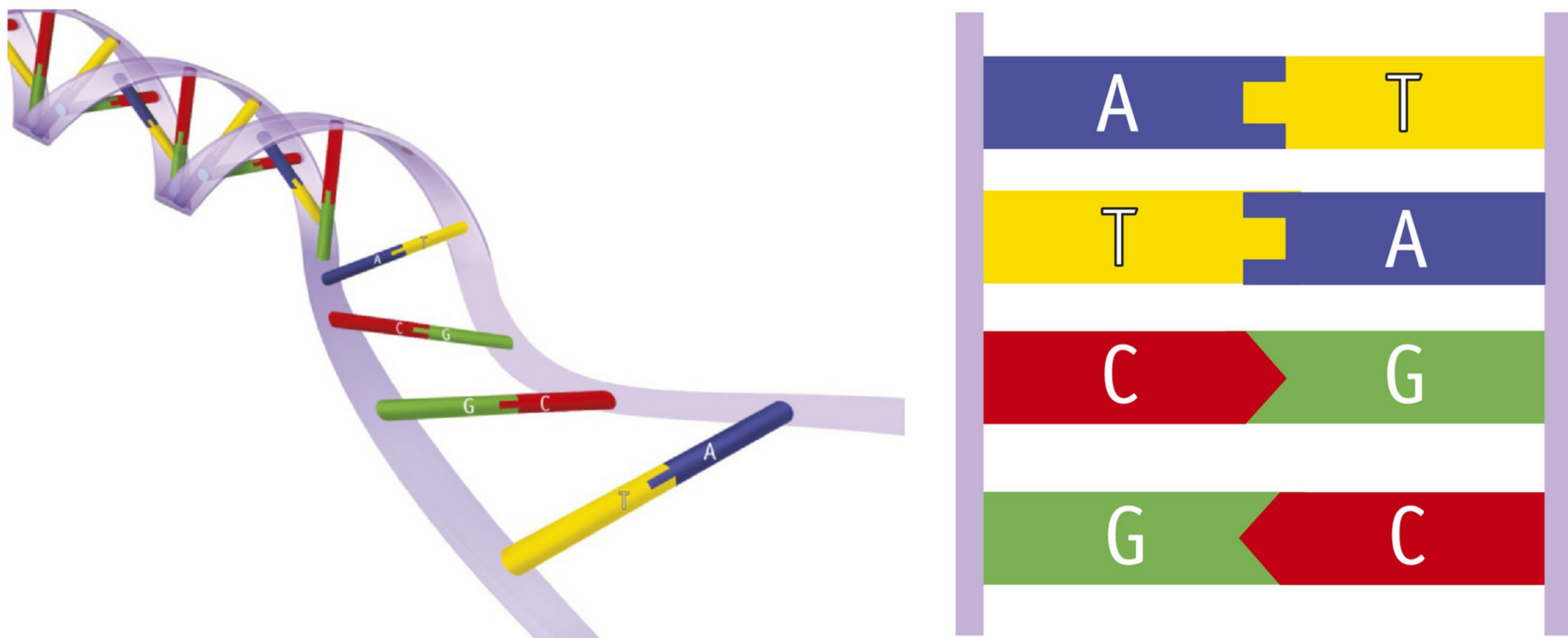
THE STRUCTURE OF DNA

You can picture DNA as a spiral staircase with more than a million steps. Each step in the staircase consists of two units that fit together exactly. There are four types of units, which form two pairs (see figure 22). These units are called bases and they are referred to by the letters A, T, C and G. A and T always form a pair and so do C and G.

A DNA chain contains information about hundreds to thousands of characteristics, and thousands of bases are needed for each characteristic. A characteristic is determined by the order in which the bases A, T, C and G appear. Such a piece of DNA is called a **gene**. Taken together, all the genes contain all the information the cells in your body need to be able to function. Cells only use the genes they themselves need. The other genes are not active. Which genes are active depends on where in the body the cell is.

WB EXERCISES 21 AND 22, PAGE 83

▼ **Fig. 22** The structure of DNA.



1 a DNA molecule looks like a long spiral staircase

2 A and T always form a pair, and so do C and G

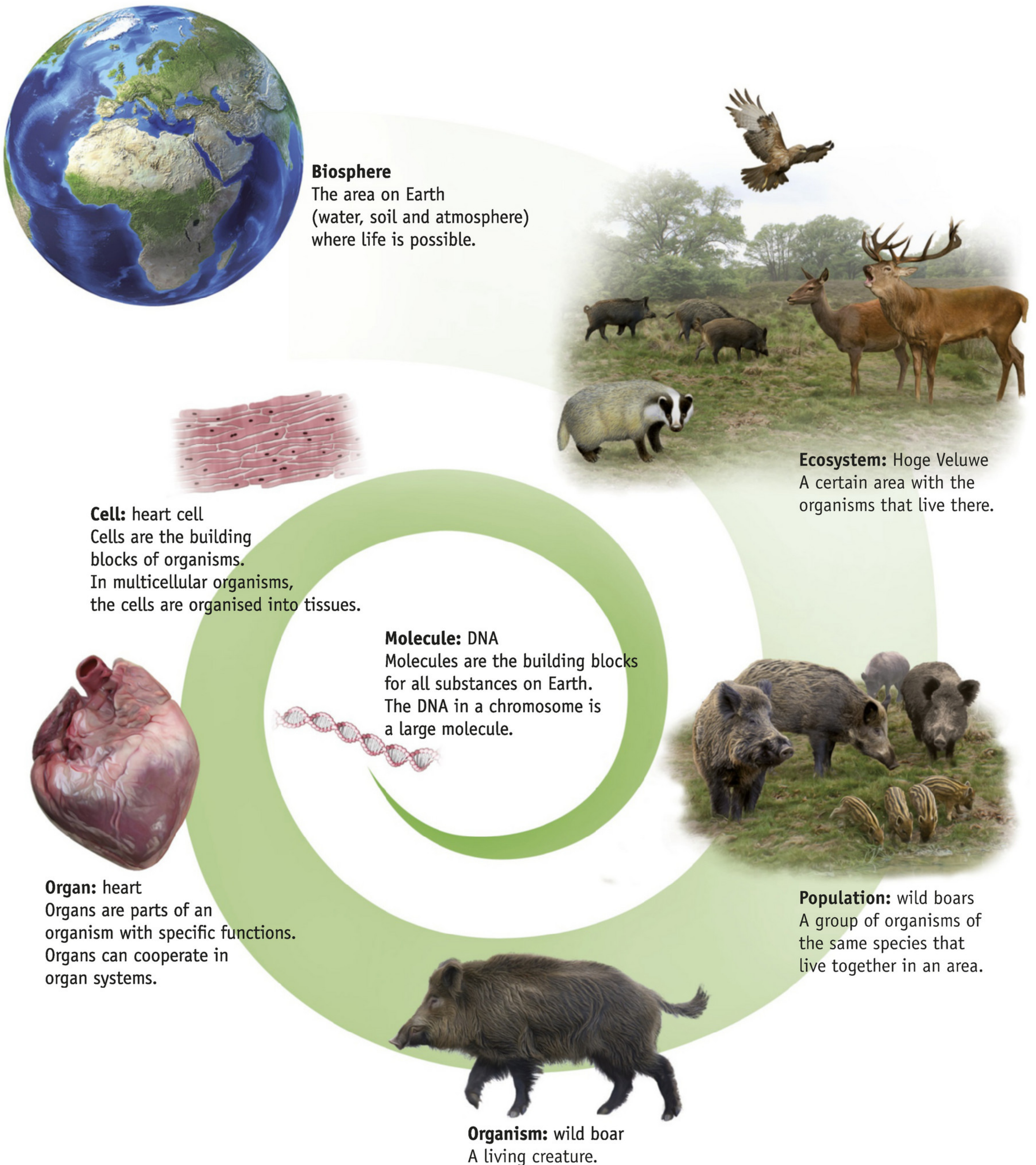
6 Levels of biology

In the previous basic materials, you learned that organisms are made up of smaller units. A person consists of cells, but those cells are not just arranged randomly in the body. They are organised into bigger units, such as tissues and organs. Cells themselves are also made up of smaller units, such as the cell membrane, plastids and chromosomes. Ultimately all these parts are made up of molecules, such as DNA, proteins and fats.

Biologists study life at different levels. These levels are shown in figure 23. There are a lot of wild boars on the Hoge Veluwe and a lot of research is done on them. Scientists study the DNA of these wild boars, for example. In Basics 5, you learned that DNA contains the information for everything that happens in a cell. It is a very large, complex molecule. Molecules are the building blocks for all substances. In DNA research, you do research at the level of **molecules**. You can also study cells or tissues. We say then that you do research at the **cellular** level. Organs are made up of different tissues. At the level of **organs**, you can study how organs or organ systems work. In an organism, different organs and organ systems work together. Organisms live together in groups. For instance, a big group of wild boars lives on the Hoge Veluwe. You call a group of organisms that live together and reproduce together a **population**. The rabbits on the Hoge Veluwe form another population. An area like the Hoge Veluwe, where different populations of plants and animals live, is called an **ecosystem**. There are many different ecosystems on Earth. In the Netherlands you have woods, heathland, dunes and lakes, for instance. These are all ecosystems. An ecosystem can be small, but it can also be very big like the tropical rainforest in Brazil. All the ecosystems combined form the **biosphere**. The biosphere is that part of Earth where life is possible.

In Unit 1 What is biology? you learned about the main themes in biology. These main themes operate at different levels. Reproduction does not only take place among organisms, for instance, but also at the level of cells. When cells divide, reproduction is taking place. Before a cell divides, a copy is created of each DNA molecule. That is reproduction too, only at the level of molecules.

▼ Fig. 23 The levels of biology.



The levels are not separate: changes at one level can have consequences for another level (see figure 24).

WB EXERCISES 23 AND 24, PAGE 84

▼ Fig. 24

Molecular biologist

Corine is a molecular biologist in a hospital who studies DNA. “Certain diseases are caused by abnormalities in the DNA. But you don’t find out you’ve got a disease because something is not quite right in your DNA. You go to the doctor with certain symptoms. The doctor may suspect you have a disease caused by the DNA. The doctor has to know exactly what disease you have to be able to treat you. These days we are able to test the DNA and say with a great degree of confidence what disease it is.”



7 Cell division

▼ Fig. 25



There are estimates that a human body consists of 100 trillion (100,000 billion) cells. That huge number was created by cell division, starting with just a single cell.

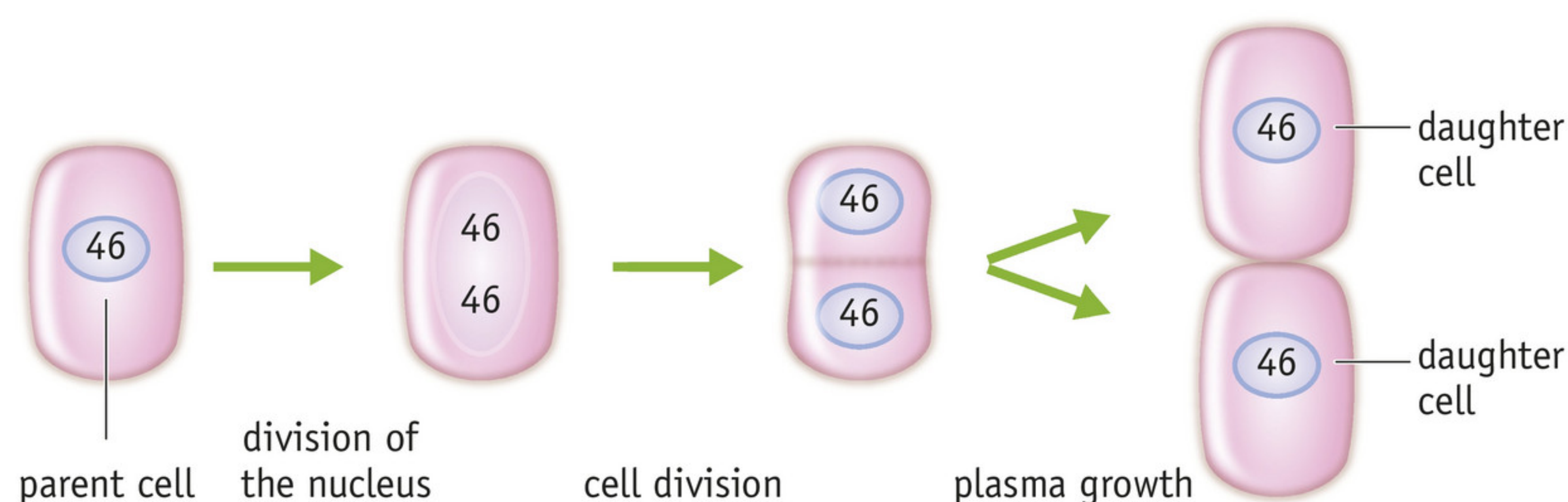
Some cells remain alive for years whereas others only live for a short while. The outer layer of your skin consists of dead cells, with millions being shed every day. They end up in your clothes and fall onto the ground. Household dust consists largely of dead skin cells. In one year you lose roughly 3.5 kg of skin. New cells are continuously being formed in your skin, so the overall number does not go down. Cells die and are replaced by new cells in all kinds of other places in your body too. You get about a million new cells every second. If more new cells are created than die, you grow.

CELL CYCLE

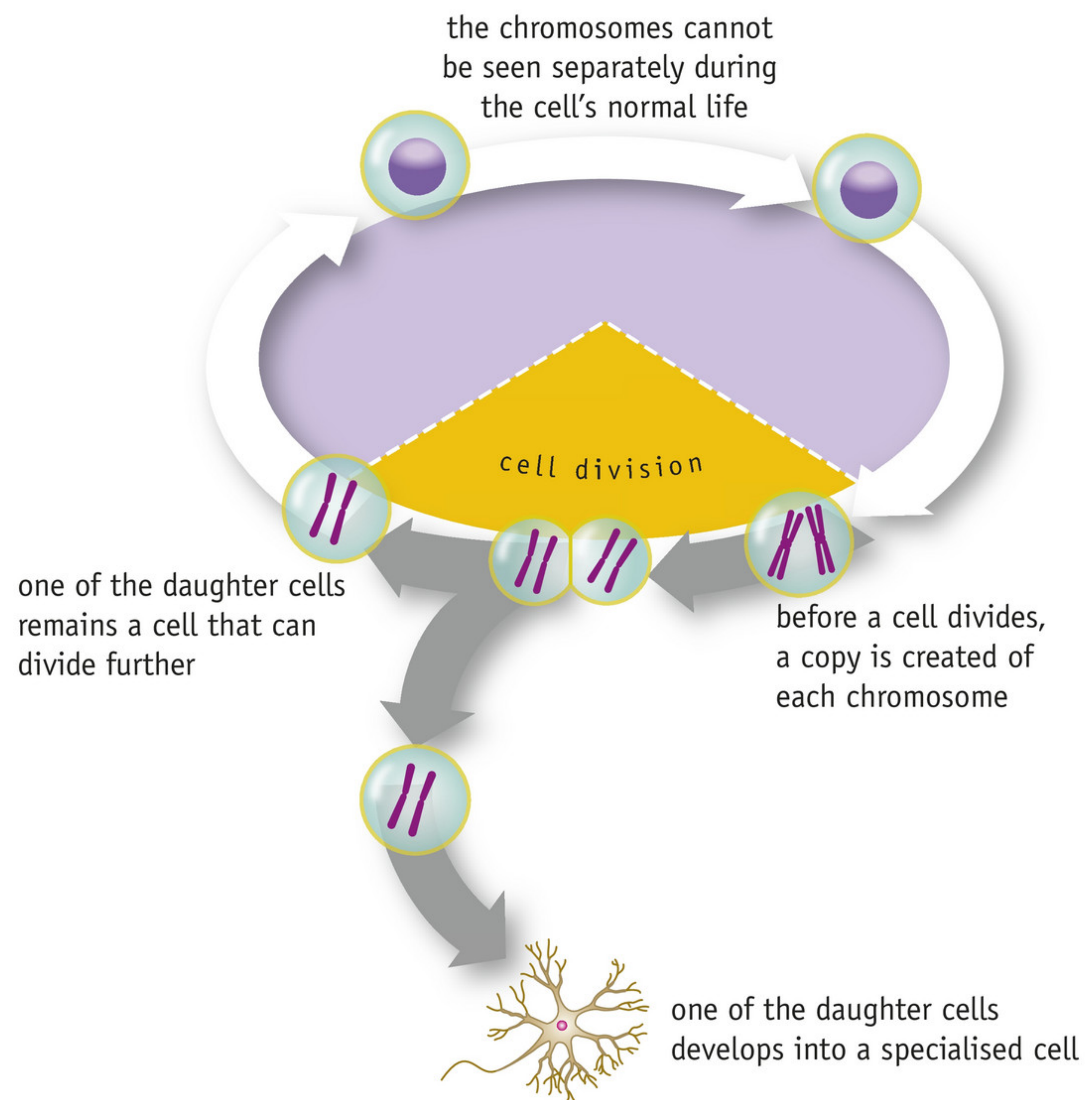
The process for creating new cells is the same for all organisms (see figure 26). First, two nuclei are created. Then the cell divides. One cell (the **parent cell**) produces two new cells (the **daughter cells**). Cell division is followed by **plasma growth**: the daughter cells get bigger as the amount of cytoplasm increases.

Before the two nuclei are created, an accurate copy is made of each chromosome. Then the two nuclei are formed, each getting a full set of chromosomes. So after the cell division, each daughter cell has just as many chromosomes as the parent cell.

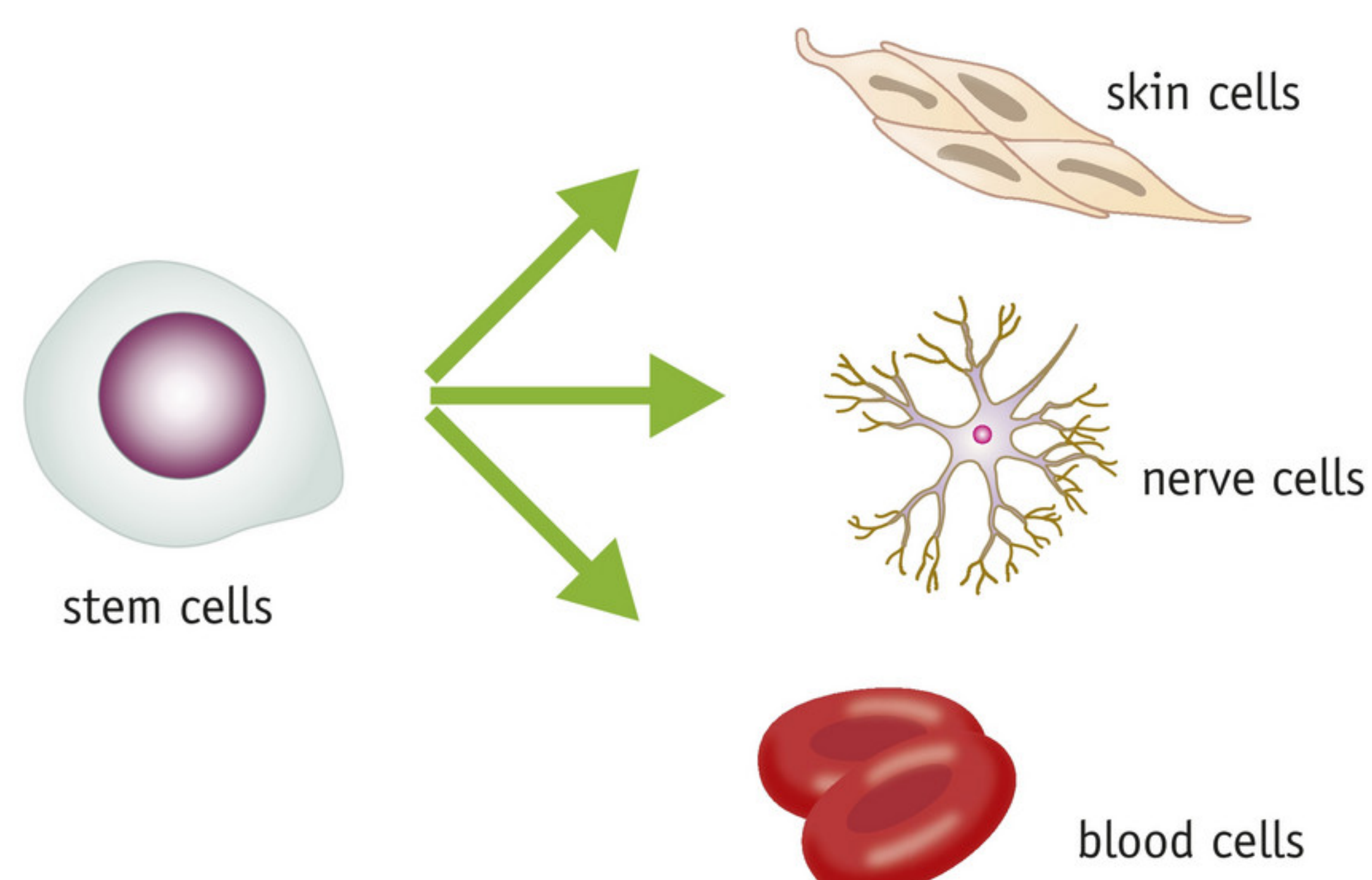
▼ Fig. 26 The creation of new cells (diagram).



After cell division, one of the daughter cells develops into a specific type of cell. If the dividing cell is in the muscles, this might be a muscle cell, but if the cell is in the skin, a skin cell will be created. The other daughter cell remains a cell that can divide further; it does not become a specialised cell (see figure 27). In the next cell division, this cell can produce another specialised cell.

▼ **Fig. 27** The cell cycle.

Cells that are capable of dividing can be found in all your body's tissues. These cells are responsible for growth and the recovery of tissues. They are called **stem cells**. Some stem cells are more specialised than others. Most stem cells can only develop into cells for the tissue in which they are found. The stem cells of an embryo (an unborn child) are often able to develop into the cells of many different kinds of tissue (see figure 28).

▼ **Fig. 28** The cells of different kinds of tissue can develop from the stem cells of an embryo.

8 Stomata

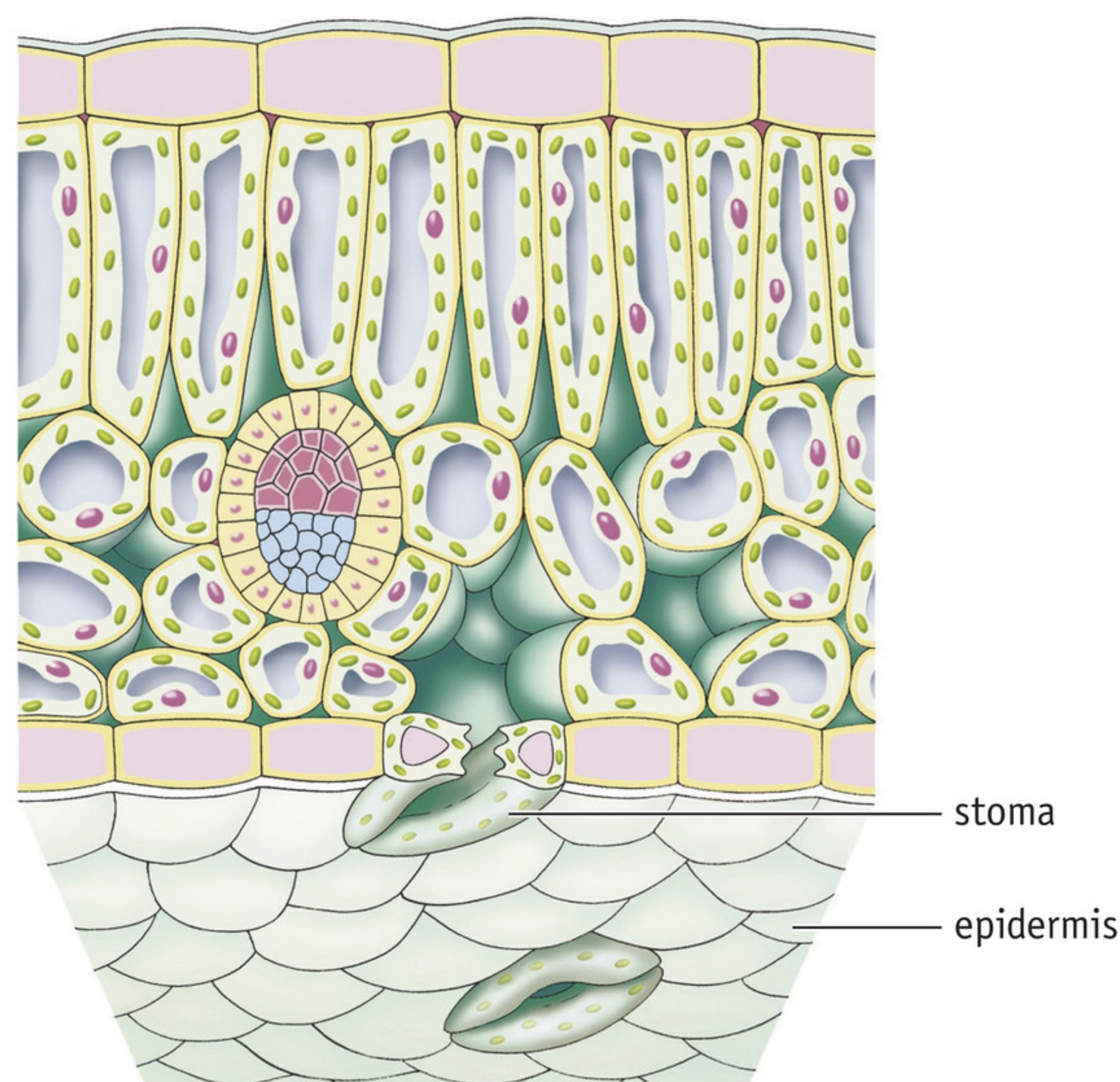
▼ **Fig. 29** Stoma (Tradescantia leaf, 600×).



You learned in Unit 2 (Plants) that water and carbon dioxide are needed for photosynthesis. Plants take up water with minerals from the soil. Plants absorb carbon dioxide from the air. In photosynthesis, oxygen is produced. Plants release oxygen into the air. In many parts of a leaf, two cells can be found with a small opening in between. These cells plus the opening are called a **stoma** (see figure 29).

Figure 30 shows a drawing of part of a leaf. You can see that there are a lot of open spaces between the cells of a leaf. Both the underside and the upper side of a leaf consist of a layer of cells: the **epidermis**. The stomata (the plural of 'stoma') are found between the epidermal cells. Many plants have more stomata on the undersides of their leaves than on the top.

▼ **Fig. 30** Cross section of a leaf.



In Unit 2 (Plants), you learned that leaves become limp if they lose a lot of water through evaporation. Water evaporates mainly through the stomata. If a plant is in danger of losing too much water through evaporation, the stomata close up. This means that less water is able to evaporate from the leaves.

WB EXERCISE 27, PAGE 88

Summary

OBJECTIVE 1

You must be able to distinguish between the organs, organ systems, cells and tissues in the structure of an organism. You also need to know what organ donation is.

- Organ: a part of an organism with one or more functions.
 - Examples: stomach, liver, lung, heart, eye.
- Organ system: a group of organs that work together and perform a specific function together.
 - Examples: respiratory system, skeletal system, circulatory system, muscular system, digestive system and nervous system.
- Cells: the building blocks of organisms.
- Tissue: a group of cells of the same type.
 - Examples: bone tissue, cartilage, muscle tissue, nerve tissue.

Many tissues have extracellular material between the cells.
- In organ donation, someone provides another person with an organ or tissue.
 - Donor: someone who provides an organ or tissue.

OBJECTIVE 2

You must be able to name the organs in a figure of a torso and of a cross section of a human torso.

- The diaphragm divides the human torso into the chest cavity and the abdominal cavity.
 - Some of the organs in the chest cavity: gullet, windpipe, lungs, main artery, main vein and heart.
 - Some of the organs in the abdominal cavity: gullet, stomach, liver, small intestine, large intestine, kidneys, main artery and main vein.

OBJECTIVE 3

You must be able to name the key organs in figures of organ systems.

- Respiratory system: includes windpipe, bronchus, lung.
- Skeletal system: includes skull, backbone, ribs, thigh bones.
- Circulatory system: includes heart, main artery, main vein.
- Muscular system: includes biceps, stomach muscle, thigh muscle.
- Digestive system: includes gullet, stomach, liver, small intestine, large intestine.
- Nervous system: includes brain, spinal cord, nerves.

OBJECTIVE 4

You must be able to name the parts of a microscope and give their features and functions.

- The parts of a microscope are:
 - arm: where you hold onto the microscope;
 - eyepiece lens: the top lens and the one you look through;
 - tube: the tube containing the eyepiece lens;
 - objective lenses: the bottom lenses;
 - revolving nosepiece: rotatable disc holding the objective lenses;
 - coarse focusing knob: for basic focusing;
 - fine focusing knob: for precision focusing;
 - stage: you place the specimen on this;
 - stage clips: you hold the specimen in place with these;
 - bulb: this sends light through the lenses;
 - diaphragm: controls the amount of light passing through the lenses.
- The eyepiece lens and the objective lenses determine the magnification of the microscope.
 - The microscope's total magnification = magnification by eyepiece lens × magnification by objective lens.

OBJECTIVE 5

You must be able to name the parts of a cell and give their features and functions.

- The parts of a cell that have their own function are called cell organelles.
 - Cytoplasm (cell plasma): a fluid consisting of water with dissolved substances.
 - Cell membrane: a thin layer that makes up the outer layer of the cytoplasm and controls the uptake and secretion of substances.
 - Nucleus: controls everything that happens in the cell. The nucleus is surrounded by the nuclear membrane.
 - Vacuole: a 'sac' filled with sap. Most plant cells contain one large vacuole.
 - Plastids: granules in the cytoplasm. Chloroplasts, chromoplasts and amyloplasts are all plastids.
- Cell wall: a strong layer surrounding the cell.
 - Cell walls are not part of the cell; they are extracellular material.
 - Animal cells do not have cell walls.

OBJECTIVE 6

You must be able to name the differences between animal cells and plant cells.

Parts that are found in both plant and animal cells	Parts that are found in plant cells but not in animal cells
cytoplasm	chloroplasts
cell membrane	chromoplasts
nucleus	amyloplasts
nuclear membrane	large central vacuole
	cell wall

OBJECTIVE 7

You must be able to name the characteristics of chromosomes and describe the structure of DNA.

- Each species of organism has a fixed number of chromosomes in every cell nucleus.
 - Every body cell in humans has a nucleus containing 46 chromosomes.
- The chromosomes control everything that happens in the cell.
 - Chromosomes: thin ‘threads’ in every nucleus.
 - Chromosomes are only visible when a cell divides.
 - Chromosomes consist largely of DNA.
 - The DNA contains the information for inherited characteristics.
- DNA consists of two strands to which bases are attached.
 - There are four different bases in DNA. They are given the letters A, C, G and T.
 - The bases form pairs between the strands: A pairs up with T and C with G.
 - The order in which the bases appear in the DNA gives the information for the characteristics.
- Gene: the part of the DNA with the information for a single characteristic.
 - Only a small proportion of all the genes in a cell are active.
 - The location of a cell in the body determines which genes are active.

OBJECTIVE 8

You must be able to name the different levels of biology.

- Biologists study life at different levels.
 - Molecule: molecules are the building blocks for substances.
 - Cell: organisms consist of one or more cells. In multicellular organisms, cells are organised into tissues.

- Organ: a part of an organism with a specific function. Organs are made up of different tissues. Organs can work together in organ systems.
- Organism: a living creature.
- Population: a group of organisms of the same species that live together in an area.
- Ecosystem: a specific area including all the organisms living there.
- Biosphere: that part of Earth in which life is possible.

EXTRA OBJECTIVE 9

You must be able to describe how a cell divides.

- New cells are created through cell division.
 - New cells are necessary for growth and to replace cells that have died off.
- The cell cycle:
 - Before a cell divides, a copy is created of each chromosome.
 - The chromosomes become visible.
 - Two nuclei are created, each with a full set of chromosomes.
 - The cell divides. The cell that is dividing is called the parent cell. The cells that are created are called the daughter cells.
 - Plasma growth: the daughter cells grow because cytoplasm is made.
 - After cell division, the daughter cells contain the same information as the parent cell.
- Stem cells are cells that can divide and produce various specialised cells.
 - Only one of the daughter cells resulting from cell division can develop into a specialised cell. Specialised cells are not usually able to divide further.

EXTRA OBJECTIVE 10

You must be able to name the characteristics and functions of stomata.

- Stoma: a small opening in the epidermis of leaves.
 - Epidermis: a layer of cells on the underside and the upper side of a leaf.
 - Most plants have most of their stomata on the underside of the leaves.
- Stomata can open and close.
 - Open stomata let air in and out of the leaves. They also let water evaporate through the leaves.
 - If a plant is in danger of losing too much water through evaporation, the stomata close up.

SKILLS AND COMPETENCIES

BASICS

- You have learned how to use a microscope.
- You have learned how to prepare a specimen.
- You have practised making drawings.

EXTRA

- You have learned how to prepare a specimen from the epidermis of a leaf.
- You have practised using the microscope.
- You have practised making drawings.

The diagnostic test does not include any questions about these competencies/skills.

You have met a pathologist and a molecular biologist in this unit. You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

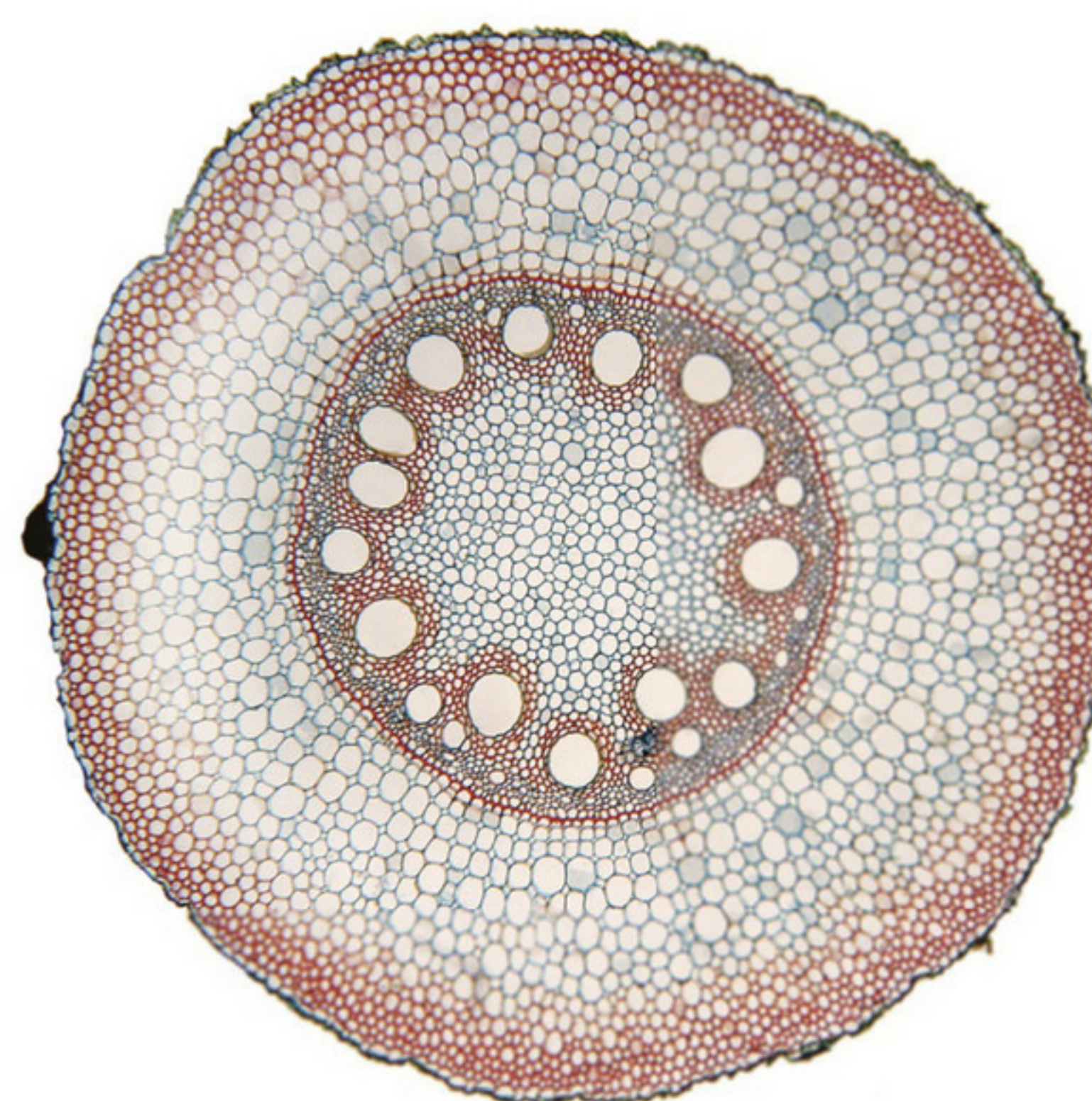
Answer the following multiple choice questions. Use figure 31 for questions 1 and 2.

- 1 Which letter indicates the donor in the drawing in figure 31?
 - A Letter P.
 - B Letter Q.
 - C Letter R.
- 2 Is a kidney an example of an organ, an organ system or a tissue?
 - A An organ.
 - B An organ system.
 - C A tissue.
- 3 The following are parts of an organism: cell – organ – organ system – tissue.
What is the correct order of size, from small to large?
 - A cell – organ – tissue – organ system
 - B cell – tissue – organ – organ system
 - C organ system – organ – tissue – cell

▼ Fig. 31

- 4 Figure 43 is a microscope photo of part of a plant. Can you see lots of cells in this figure or just one cell? And can you see different kinds of tissue in this figure or just one kind of tissue?
 - A Figure 32 shows just one cell but different kinds of tissue.
 - B Figure 32 shows lots of cells but just one kind of tissue.
 - C Figure 32 shows lots of cells and different kinds of tissue.

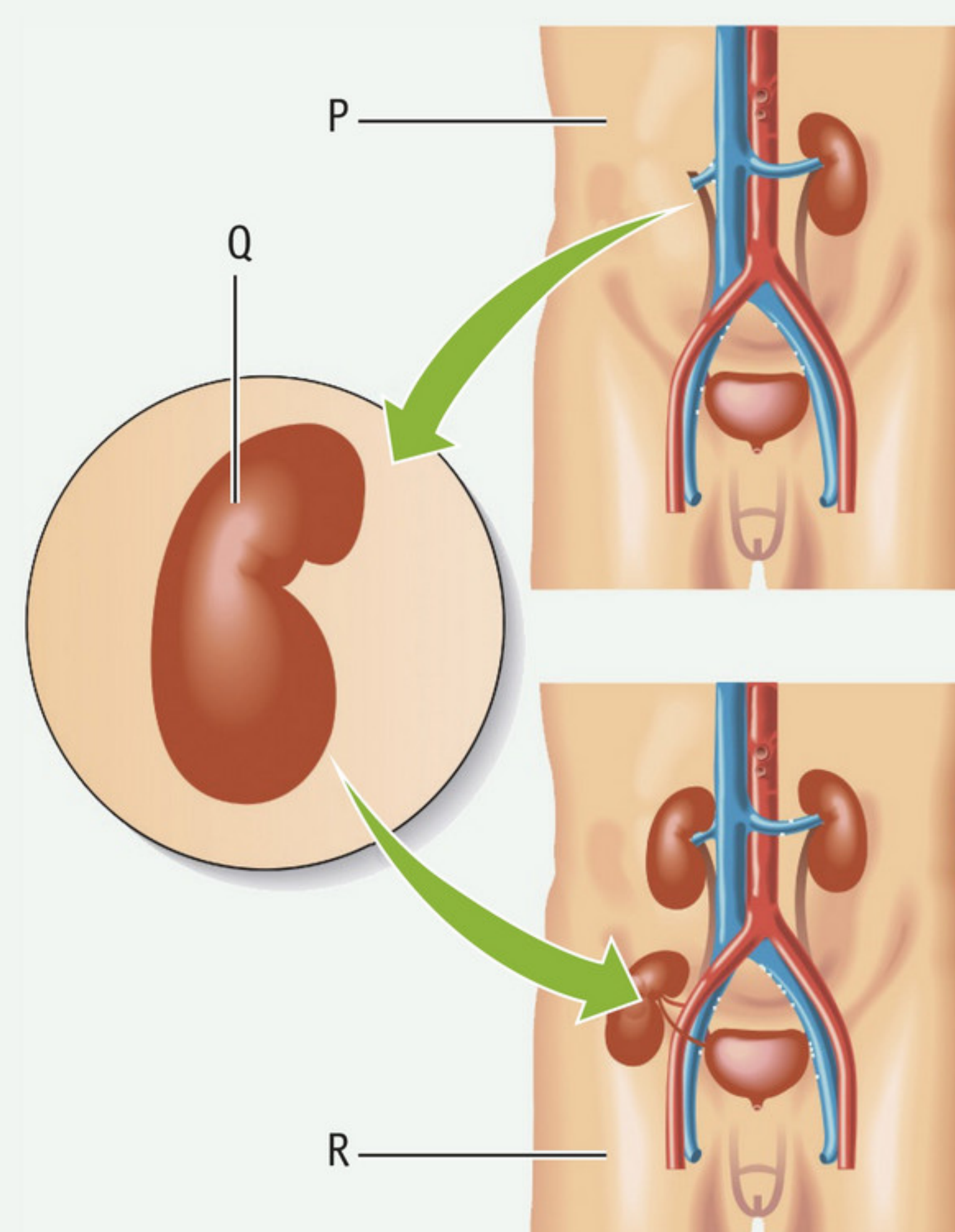
▼ Fig. 32



Kidney transplant

William is aged 48 and his two kidneys are no longer functioning properly. He takes medication and has to visit the hospital regularly.

Arnold, William's brother, has healthy kidneys and wants to help his brother. You can survive perfectly well with only one kidney. Even so, it is a difficult decision because it still means an operation. After various tests they are ready and William and Arnold are admitted to different hospital wards. First, one of Arnold's kidneys is removed. The kidney is taken at once to the transplant ward, where William has already been prepared. Arnold's kidney can now be transplanted immediately into William's body (see the drawing).



OBJECTIVE 2

Figure 33 shows a diagram of a human torso with a cross section through the torso.

- Write down the names of the numbered organs.

▼ Fig. 33

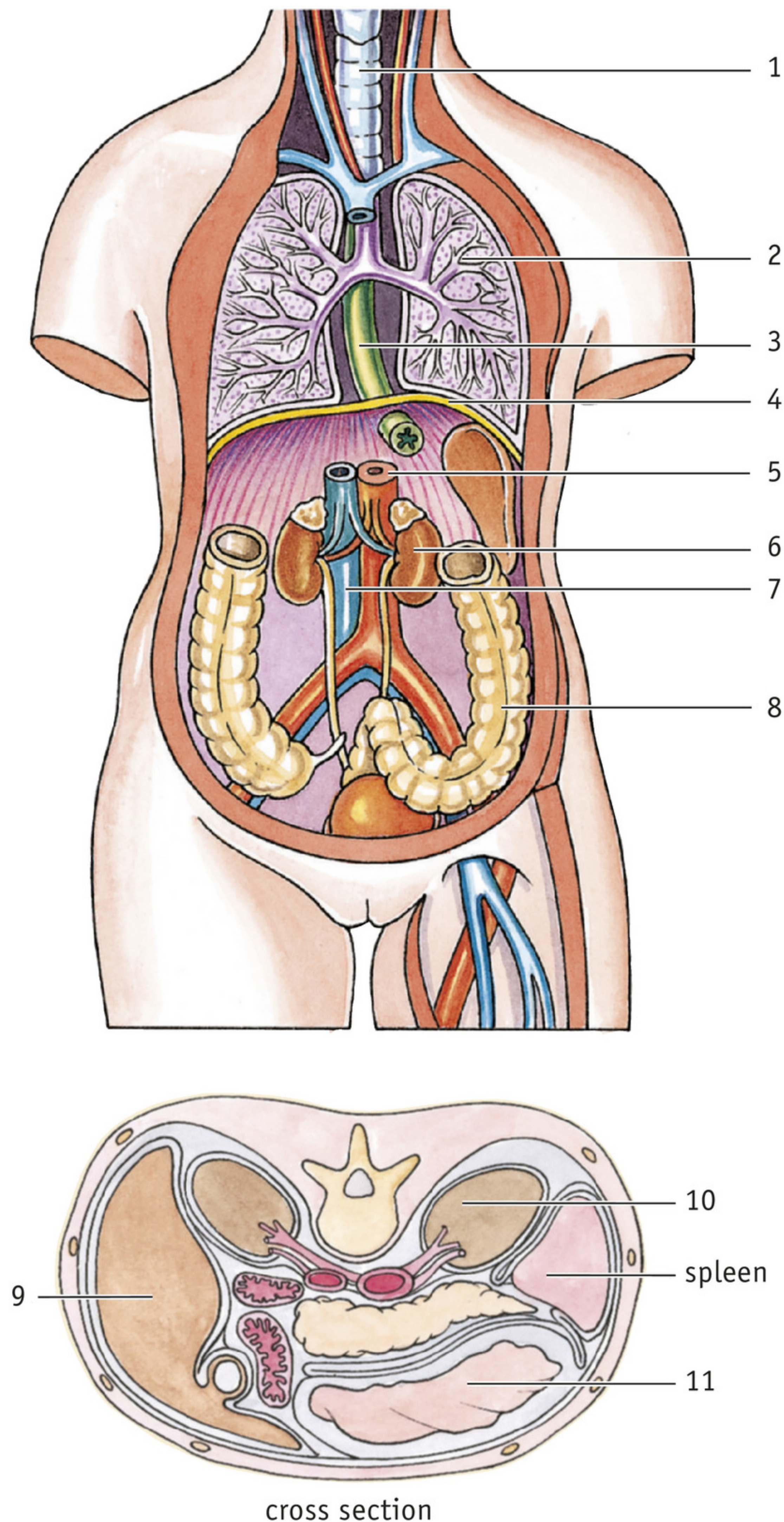
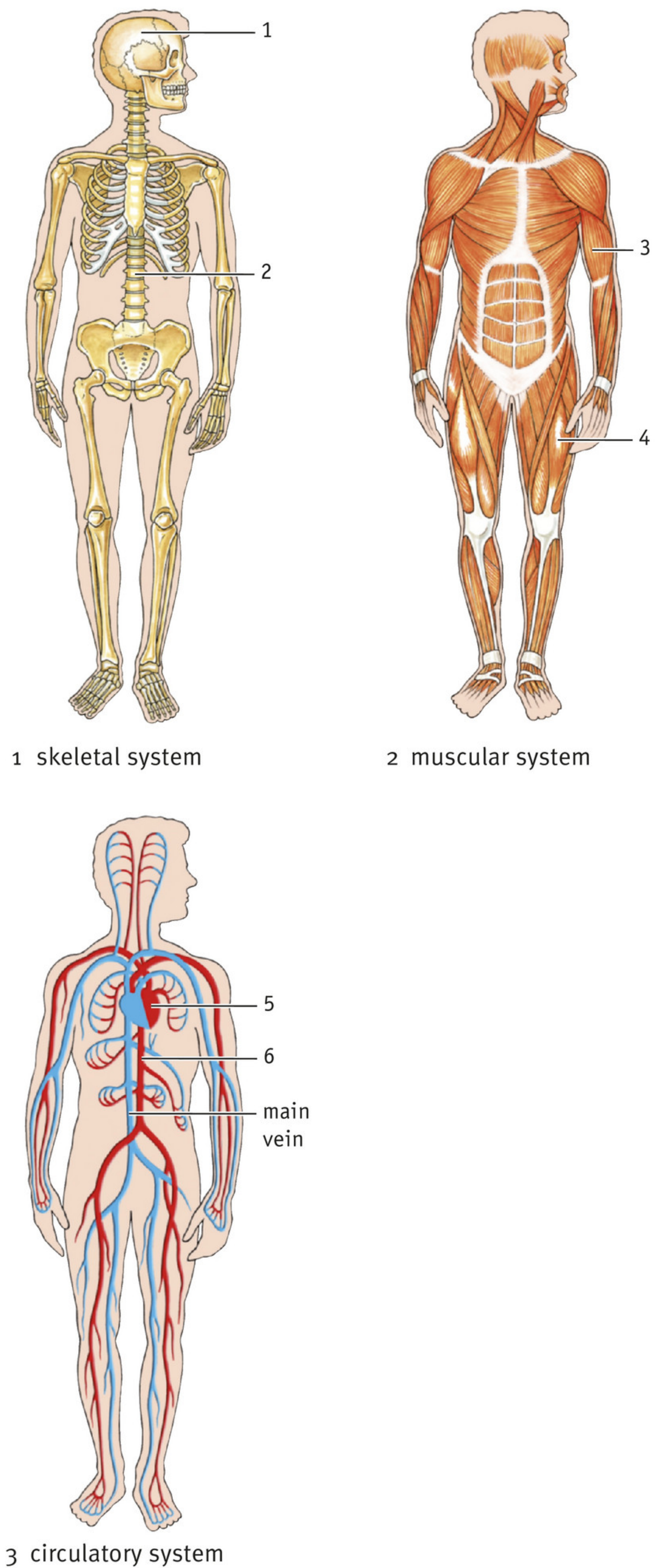
**OBJECTIVE 3**

Figure 34 shows diagrams of three human organ systems.

- Write down the names of the numbered organs.

▼ Fig. 34

**OBJECTIVE 4**

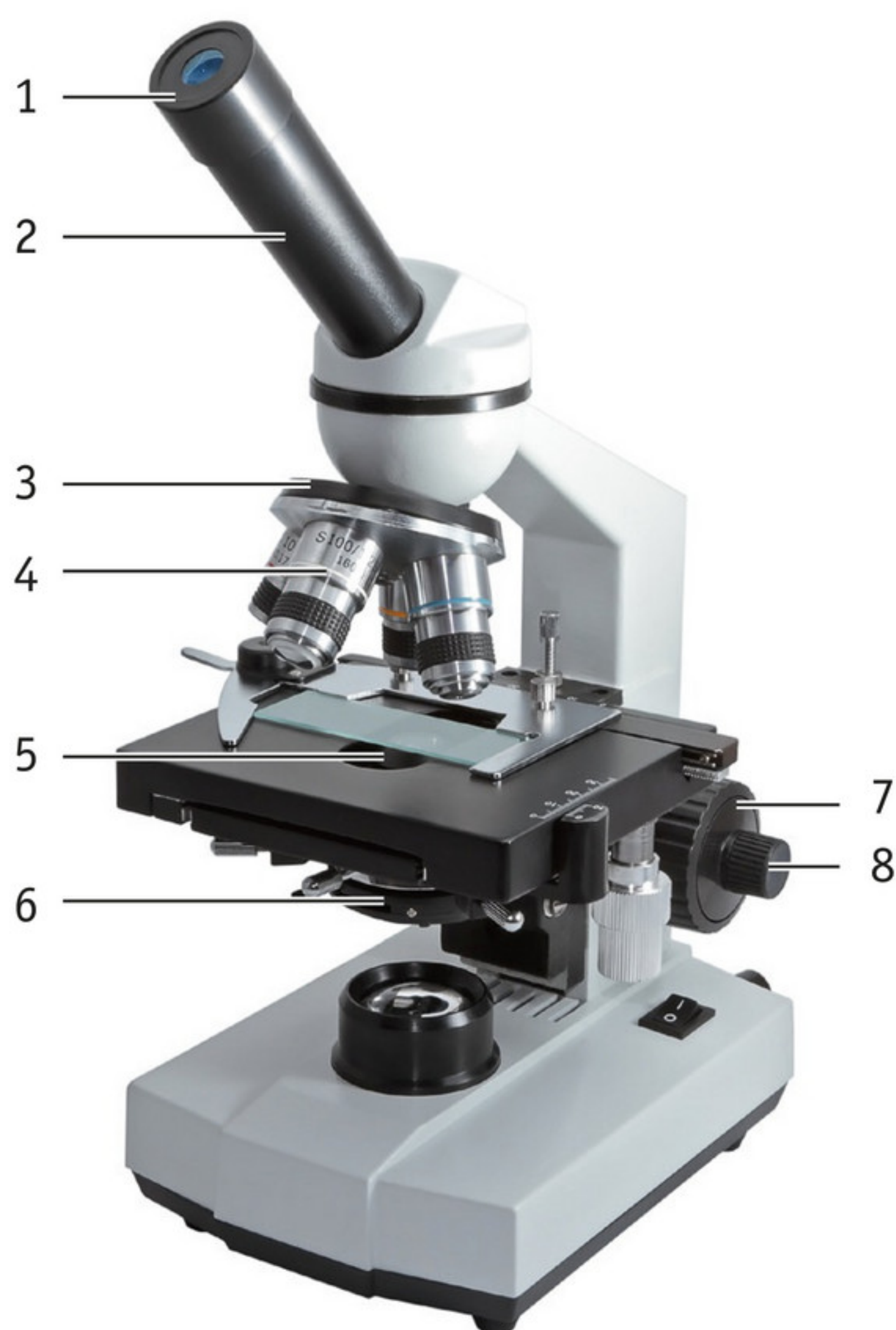
Answer the questions below.

Figure 35 shows a photo of a microscope.

- 1 What is the name of the part labelled 3?
- 2 What is the name of the part labelled 4?

- 3 What is the name of the part labelled 6?
- 4 Which number labels the tube?
- 5 Which number labels the eyepiece lens?
- 6 What is the function of the part labelled 6?
- 7 Which number labels the part that is used to focus precisely?
- 8 Which part or parts may contain a lens that magnifies objects 10 times?
- 9 A pupil wants to examine a specimen at $200\times$ magnification. He has eyepiece lenses with magnifications of $5\times$, $10\times$ and $15\times$, and objective lenses with magnifications of $4\times$, $10\times$ and $40\times$. Which combination of eyepiece lens and objective lens should he use?

▼ Fig. 35

**OBJECTIVE 5**

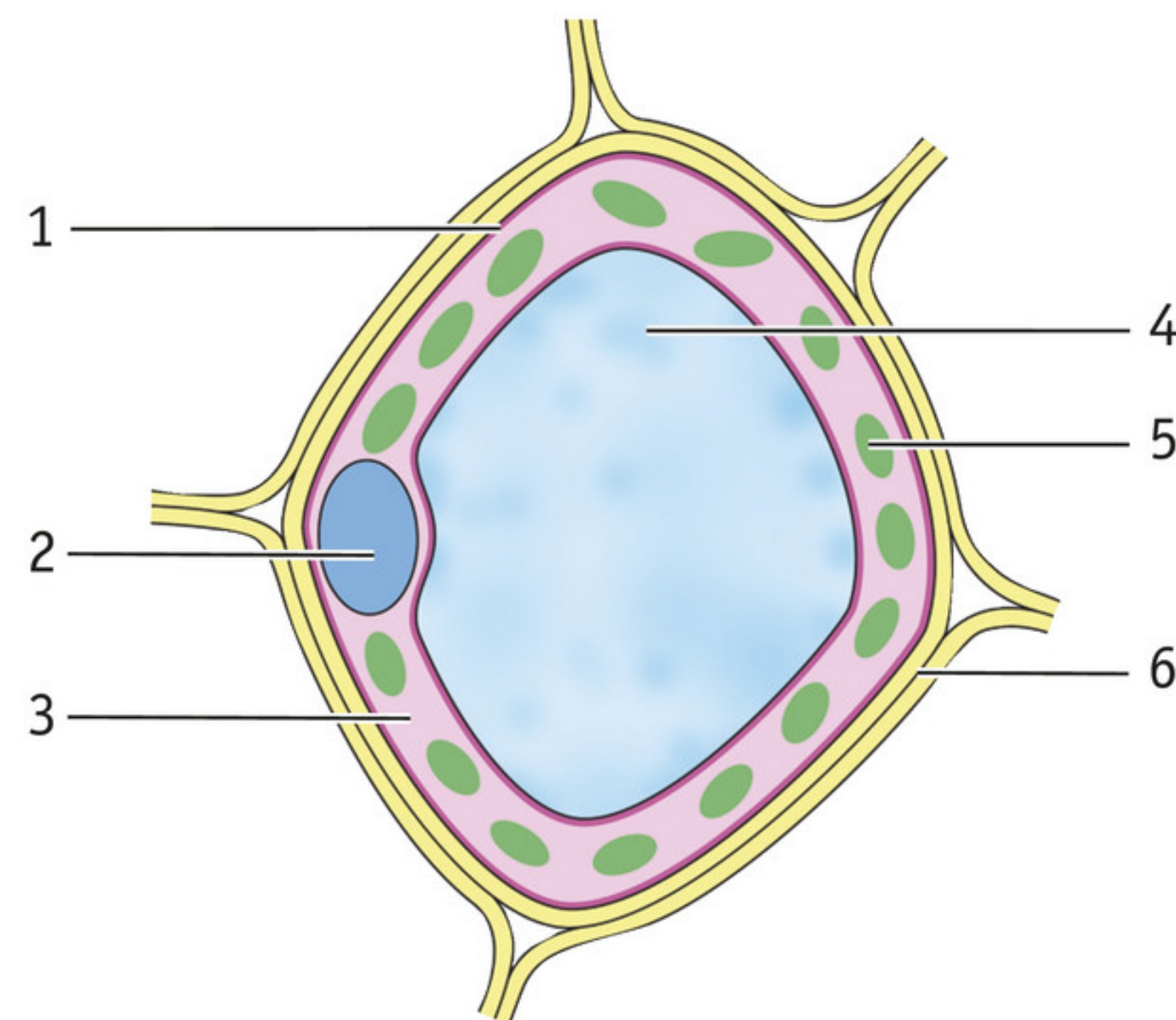
Answer the questions below.

- 1 What is the function of the cell membrane?
- 2 What is the fluid in a cell called?
- 3 Which cell organelle controls what happens in a cell?

Figure 36 is a drawing of a cell. Questions 4 and 5 are about this figure.

- 4 What features show that this must be a drawing of a plant cell?
- 5 Which of the labelled parts contains extracellular material?

▼ Fig. 36



- 6 When an orange ripens, its colour changes from green to orange (see figure 37). What change takes place in the chromoplasts?

▼ Fig. 37

**OBJECTIVE 6**

Figure 38 shows a bee orchid and a European bee-eater. You will see a list of parts of a cell in your score sheet.

- Mark with a cross those parts that are only found in the cells of the bee orchid.

▼ Fig. 38



1 bee orchid



2 European bee-eater

OBJECTIVE 7

Answer the following two-choice questions.

- 1 Certain parts of human DNA contain information about the substances that determine the colour of the eyes.
Where in a cell is this DNA?
A In the nucleus.
B In the cytoplasm.
- 2 Bodybuilders have muscular bodies.
Is such a muscular body an inherited characteristic?
A Yes.
B No.
- 3 The coloured part of your eyes is called the iris (see figure 39).
Does a cell in the iris contain 46 chromosomes?
A Yes.
B No.

▼ Fig. 39



iris

- 4 Some people think ferrets are really polecats (see figure 40) that people started to keep as pets. A study shows that the body cells in a polecat contain 40 chromosomes.
Would you expect a ferret's body cells to contain 40 chromosomes as well if ferrets really are tame polecats?
A Yes.
B No.

▼ Fig. 40 Polecat.



- 5 In DNA, the bases A, C, G and T form fixed pairs. What are these pairs?
A A paired with G and C with T.
B A paired with T and C with G.
- 6 Joe and Nathan are examining prepared specimens of muscle cells and nerve cells. They notice that the cells look really different.
Joe says that is because muscle cells and nerve cells have different genes.
Nathan says it is because different genes are active in the muscle cells than in the nerve cells.
Who is right?
A Joe.
B Nathan.
- 7 There are a lot of pictures of DNA on the Internet. Figure 41 shows one such picture.
Has the person who drew the picture shown the right number of bases?
A Yes.
B No.

▼ Fig. 41



OBJECTIVE 8

Different levels of biology are mentioned in the text for figure 42.

- On the score sheet, next to each level of biology, note down an example from the text in figure 42.

▼ Fig. 42

Pangolins endangered

Around the world, large areas of nature are disappearing because humans need more land to grow their food. This is having a big impact on many mammals, which are in danger of becoming extinct as a result. On Sumatra, for instance, the tigers live in small groups because the jungle has been cleared in many places to make way for agriculture. But the tigers are less able to reproduce in the small groups and it is more difficult for them to find food. As they are also hunted as well, their numbers are decreasing further still.

The list of endangered species also includes many unfamiliar animals. One example is the pangolin. They are found in Africa and Southeast Asia. The largest species, the giant ground pangolin, lives in the tropical rainforest and savannah of Central Africa.

Pangolins are insectivores. They mainly catch ants with their sticky tongues. They are covered in scales made of keratin. This is the same material that makes your nails and hair stiff. The sticky substance is produced in hair cells in the skin. Some parts of a pangolin's body are thought by some people to have medicinal powers. As a result, there is a lot of hunting and poaching of these animals. At the same time, their habitat is rapidly becoming smaller. Most species of pangolin are therefore endangered.



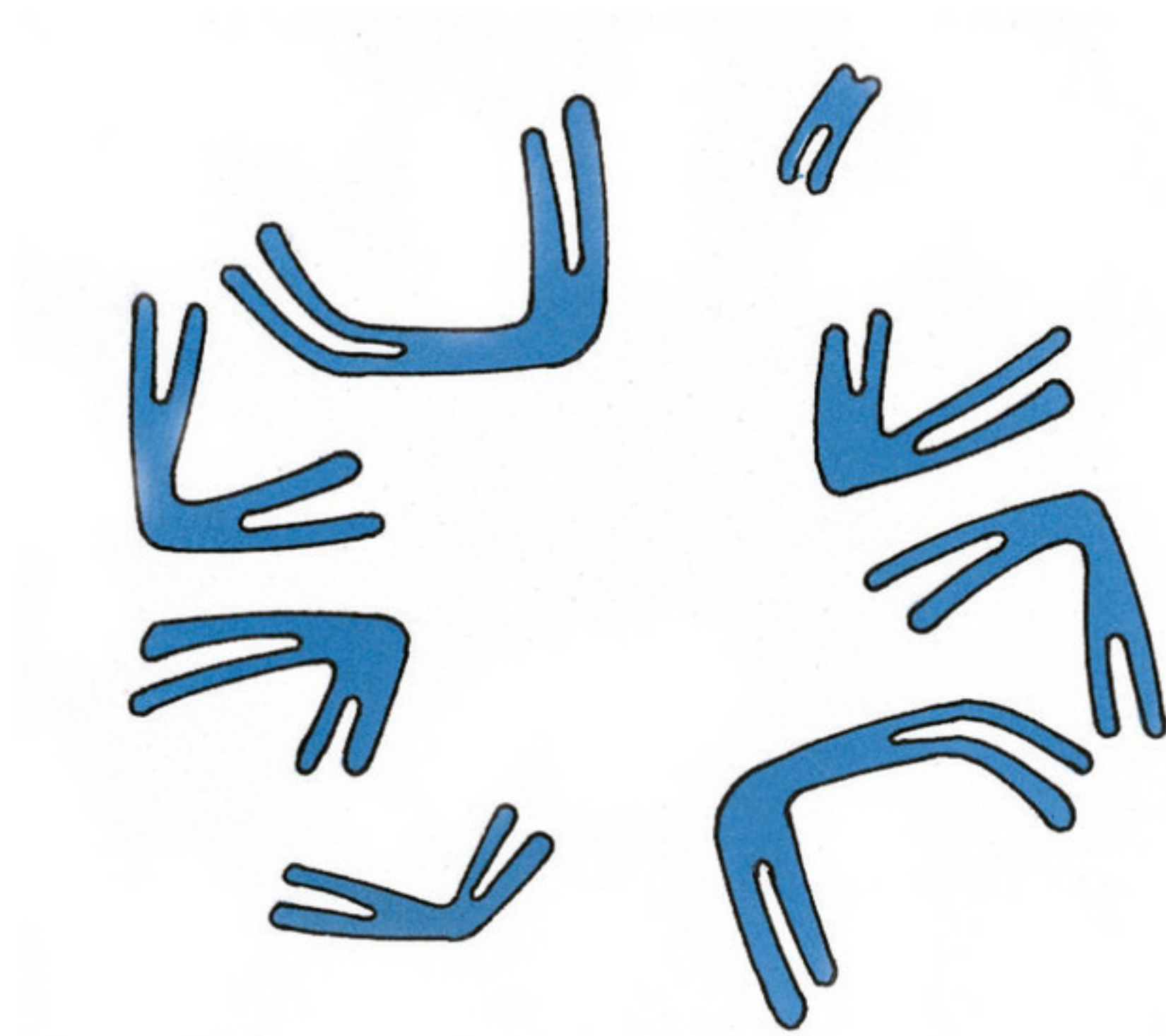
A pangolin (*Manis tetradactyla*)

EXTRA OBJECTIVE 9

Answer the following multiple choice questions.

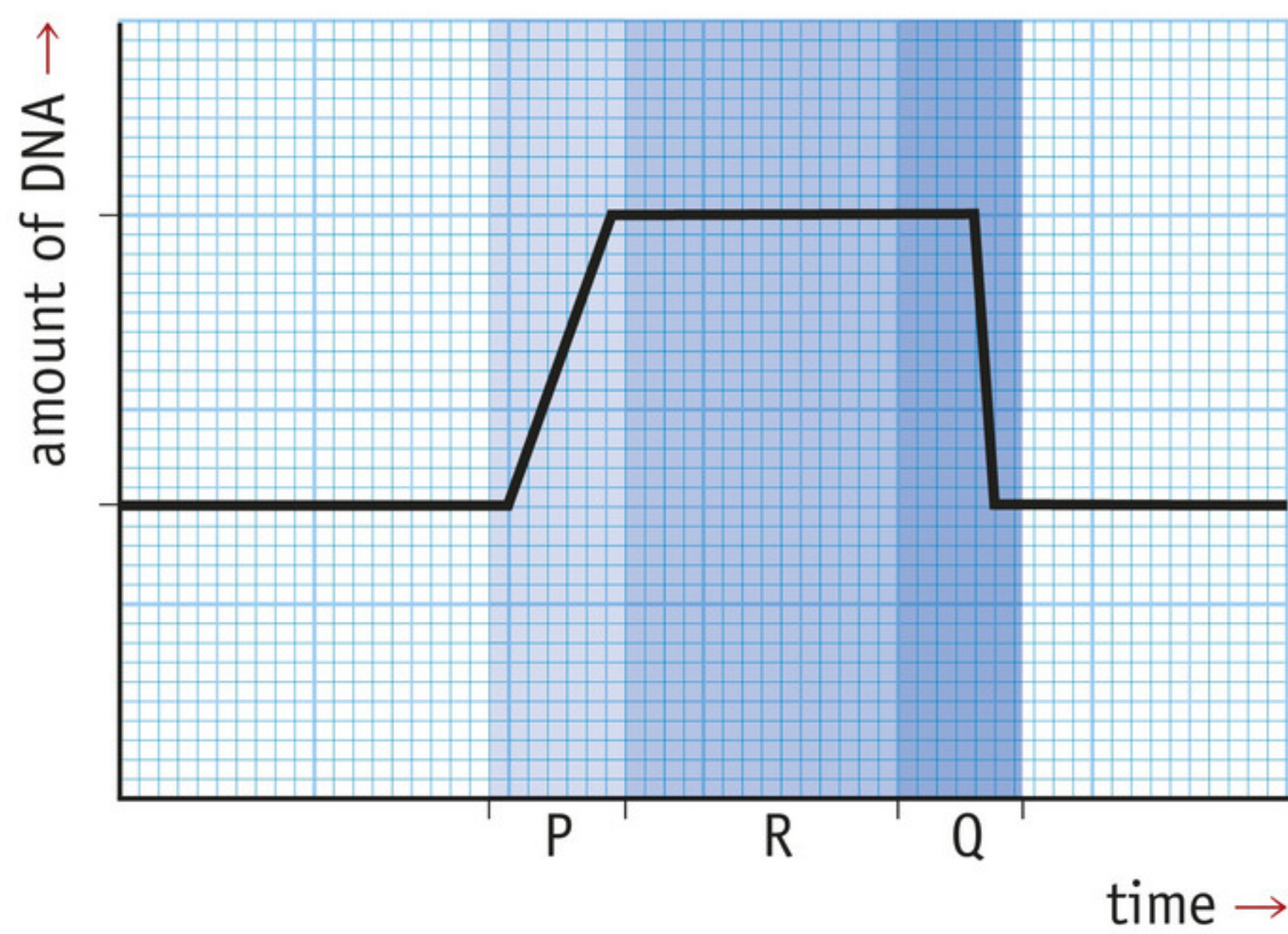
- Figure 43 shows a schematic drawing of the chromosomes in the cells of a fruit fly. How many chromosomes do the body cells of a fruit fly contain? And is this a drawing of the situation just before or just after cell division?
 - A fruit fly cell contains eight chromosomes and the drawing shows the situation just before cell division.
 - A fruit fly cell contains eight chromosomes and the drawing shows the situation just after cell division.
 - A fruit fly cell contains sixteen chromosomes and the drawing shows the situation just before cell division.
 - A fruit fly cell contains sixteen chromosomes and the drawing shows the situation just after cell division.

▼ Fig. 43



- At what point in the cell cycle does plasma growth take place?
 - Before the division of the nucleus.
 - After the nucleus divides but before the cell division.
 - After cell division.
- The graph in figure 44 shows the amount of DNA in a cell during the cell cycle. The line indicates the amount of DNA. Three periods are labelled in the graph. During which period did cell division take place in this cell?
 - During period P.
 - During period Q.
 - During period R.

▼ Fig. 44



- 4 When a woman is pregnant, certain cells start to form the heart of the unborn baby right from the beginning. There are also cells that form the brain. What determines whether a cell develops to become a heart cell or a brain cell?
- A** The genes that are present in the cell.
 - B** The location of the cell in the body.
 - C** The order of the bases A, C, T and G in the cell.

EXTRA OBJECTIVE 10

Answer the questions below.

- 1** What is the layer of cells on the underside and the upper side of a leaf called?
- 2** Where are the stomata mainly to be found in most plants: on the underside of the leaves or on the upper side of the leaves?
- 3** Figure 45 shows drawings of two stomata. Which substances can leave the leaf through the stomata?
- 4** A plant is in the sun on a dry summer's day. What will the stomata on this plant look like: like figure 45.1 or like figure 45.2

▼ Fig. 45



1 stoma

2 stoma

You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three topics. You can do the exercises for them in your workbook. Your teacher will tell you how many topics you should choose.

1 Kinship analysis

In the basics, you learned that chromosomes contain DNA and that DNA determines your inherited characteristics. In this extension you will learn about an application of our knowledge of DNA. You will isolate DNA from cells taken from your cheek lining.

▼ Fig. 46 Each human being is unique.



▼ Fig. 47

Suspects in murder case shown to be innocent

For months, the police saw an asylum seeker as the only suspect in a murder investigation. But DNA tests showed he could not possibly be the murderer. Traces of the murderer were found on the victim's body. The suspect's DNA, which was analysed as a matter of urgency, turned out to be completely different to the traces that had been found. The police have since detained five new suspects, all of whom were released following DNA tests.

People all look different. Many aspects of our appearance can vary between people, for example the colour of our hair, the colour of our eyes, the colour of our skin and the shape of our nose. That is because people never quite share the same DNA, except in the case of identical twins. Twins look the same because there are no differences in their DNA. It is possible to identify someone using their DNA because people's DNA differs.

Members of the same family look more like each other than people who are not related because children get their DNA from their parents. That also means you can use DNA to determine whether someone is your brother, your sister, your father or your mother. This is called DNA kinship analysis or familial testing.

The police can also use this information to solve crimes. Cells belonging to the offender can often be found at the scene of a crime. If the victim scratched the offender, some of the offender's skin can often be found under the victim's fingernails. Saliva, blood, hair or semen may also be found. DNA tests can be used not just to track down an offender but also to prove that someone cannot be the offender (see figure 47). In this murder investigation, a DNA kinship analysis was carried out in 2012. Tests on the murderer's DNA had already shown that it had to be a man of Western European ethnicity. About eight thousand men who lived in the area were asked for a sample of cheek lining cells. These were used to make DNA profiles (see figure 48). These tests let them find the man whose DNA was on the victim.

WB EXERCISES 1 AND 2, PAGE 91

► **Fig. 48**

CREATING A DNA PROFILE

Step 1 Isolating the DNA

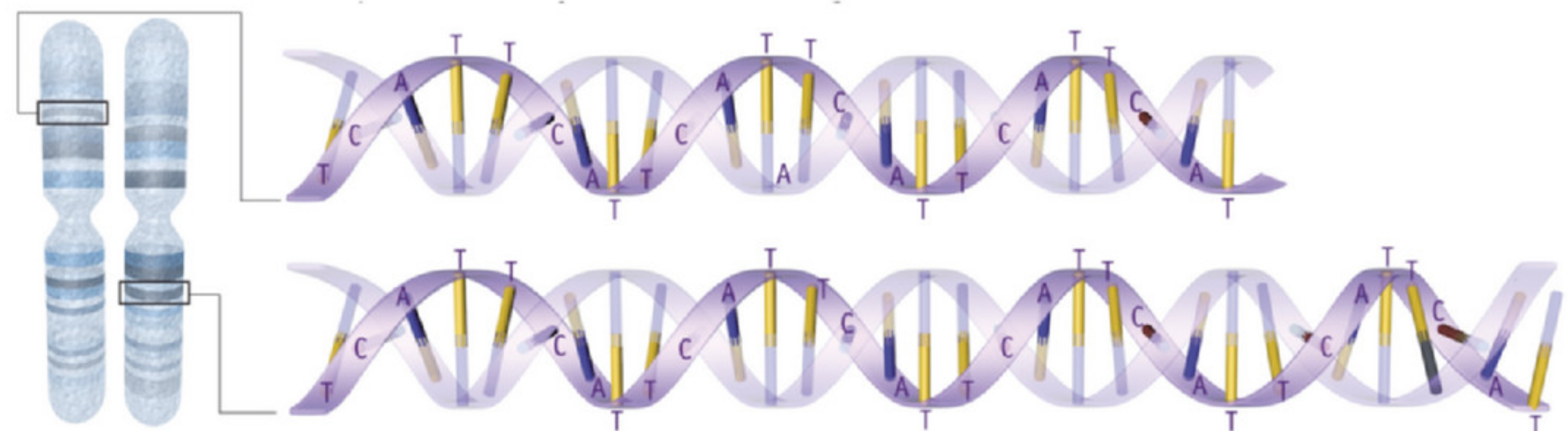
First the DNA is extracted from the cells being tested. Substances are added to the cells that make them fall apart and release the DNA.

Step 2 Pieces of DNA

There are pieces in the DNA in which the bases repeatedly appear in a certain order. However, the number of repeats can differ (see figure 48.1). Such repeats appear in several places on different chromosomes.

Each cell contains two copies of each chromosome. One copy comes from your father and the other from your mother. For instance, the sequence TCAT can appear on one of a pair of chromosomes six times, and eight times on the other chromosome. In another pair of chromosomes, the sequence GTAA may be repeated fifteen times on one chromosome, for example, and eighteen times on the other. These pieces with repeating patterns of bases (repeating pieces of DNA) can be cut from the DNA using special substances.

the repeating piece of DNA where the sequence TCAT appears six times



the repeating piece of DNA where the sequence TCAT appears eight times

1 repeating piece of DNA

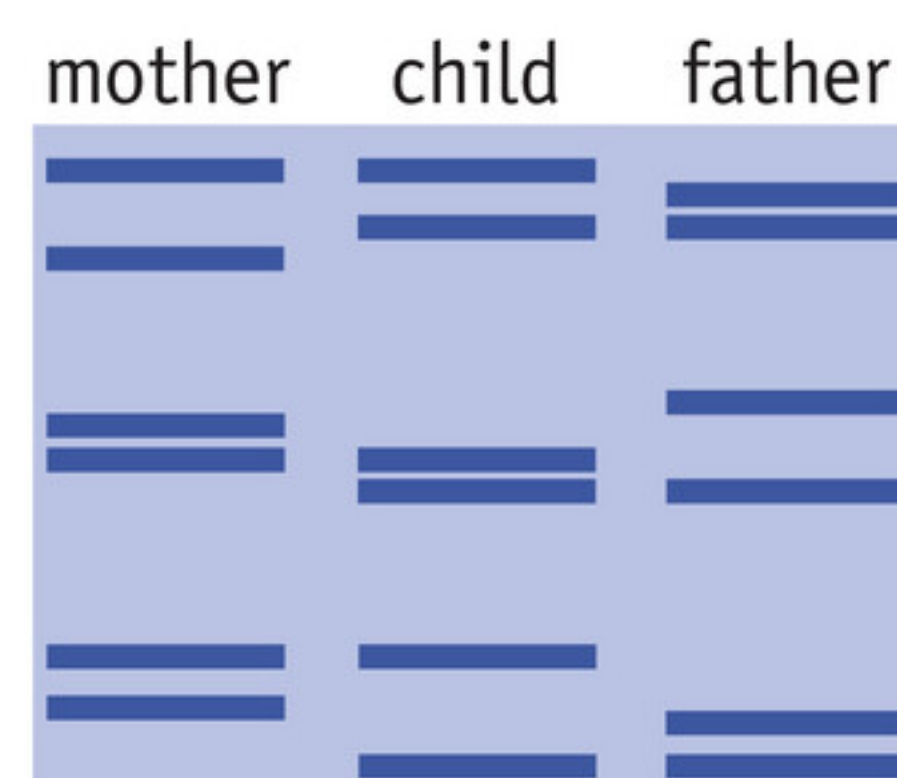
Step 3 DNA amplification

Often, there is not enough DNA for further investigation. So a special technique called amplification is used to make lots of copies of the pieces of DNA.

Step 4 Measuring

The pieces of DNA are put in a machine, where they are sorted according to length. They can then be seen as bands. Figure 48.2 shows a simplified drawing of these bands for a mother, child and father. The child's bands come from the mother or the father.

This matching can also be done using the DNA of a suspect and DNA from cells that have been found.



2 DNA profile (schematic)

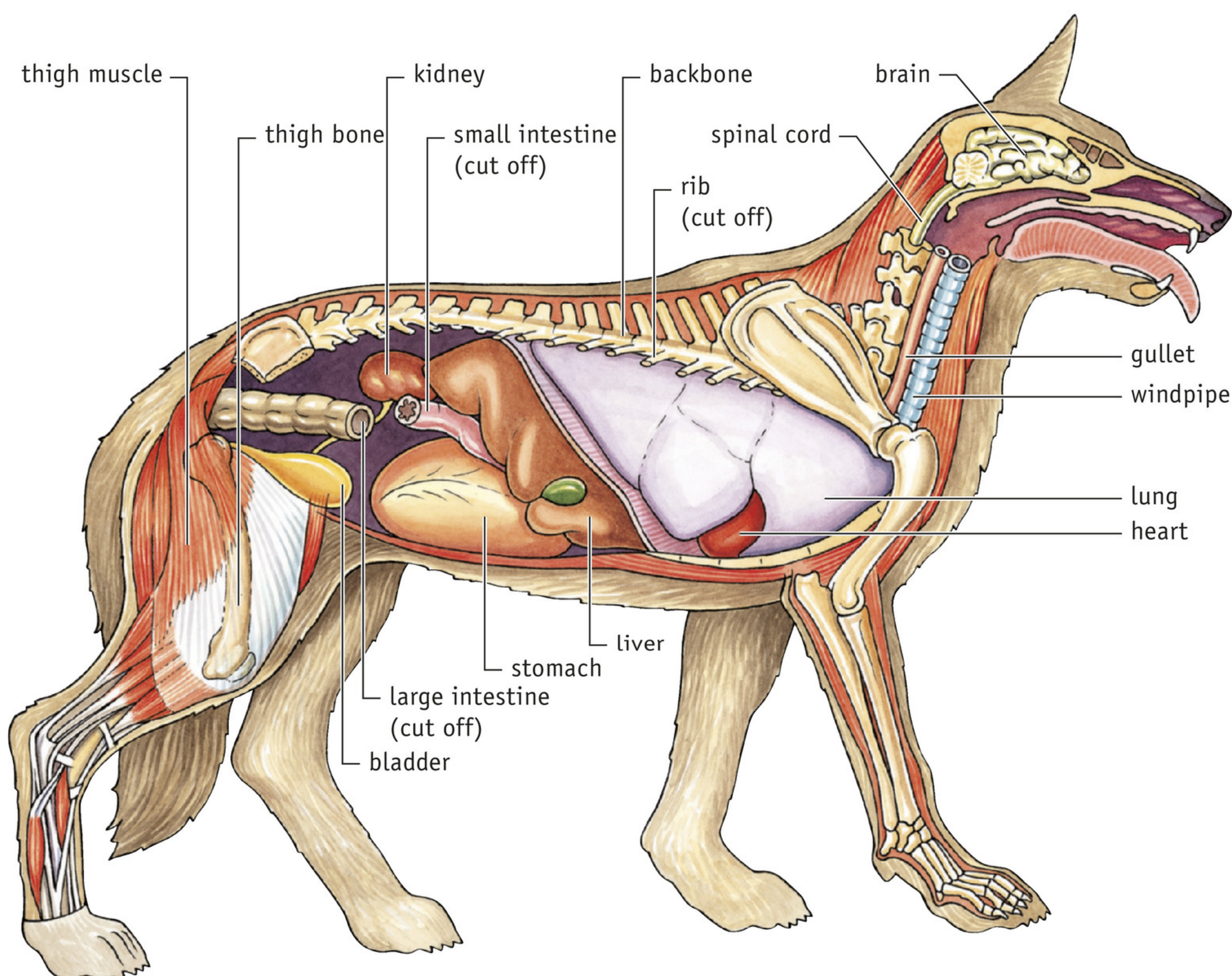
2 Organ systems in a dog

In the basics, you learned about various organ systems in humans. Most mammals have the same organ systems as humans. In this extension, you will divide the organs in a dog into different organ systems. You have to colour in a drawing.

Figure 49 shows you a diagram of some of the organs in a dog. You can divide these organs up into the organ systems you learned about in the basics: the digestive system, the skeletal system, the muscular system, the circulatory system, the respiratory system and the nervous system. The kidneys and the bladder belong to the excretory system.

WB EXERCISE 1, PAGE 93

▼ Fig. 49 Organs in a dog (schematic).

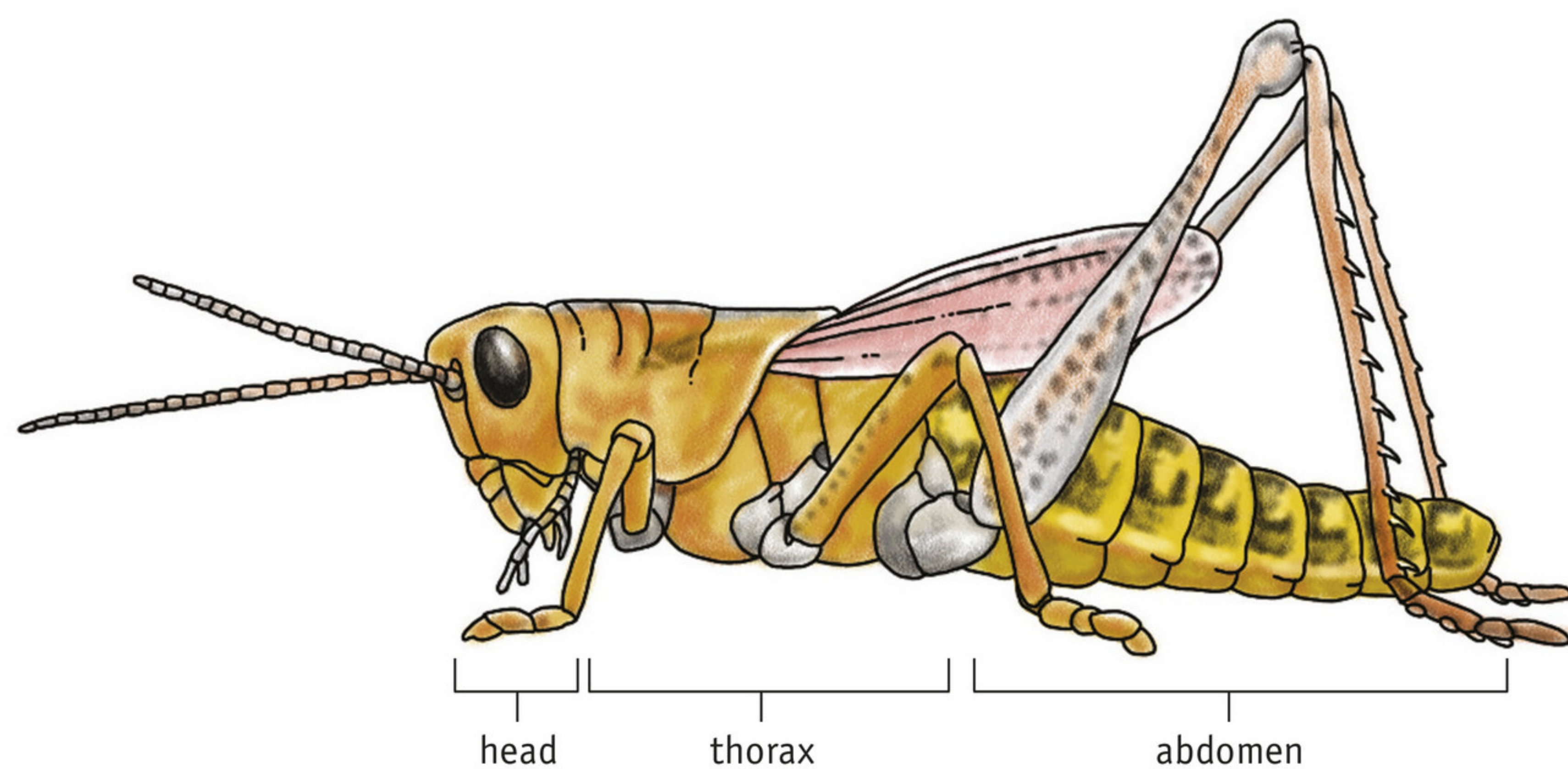


3 Organ systems in an insect

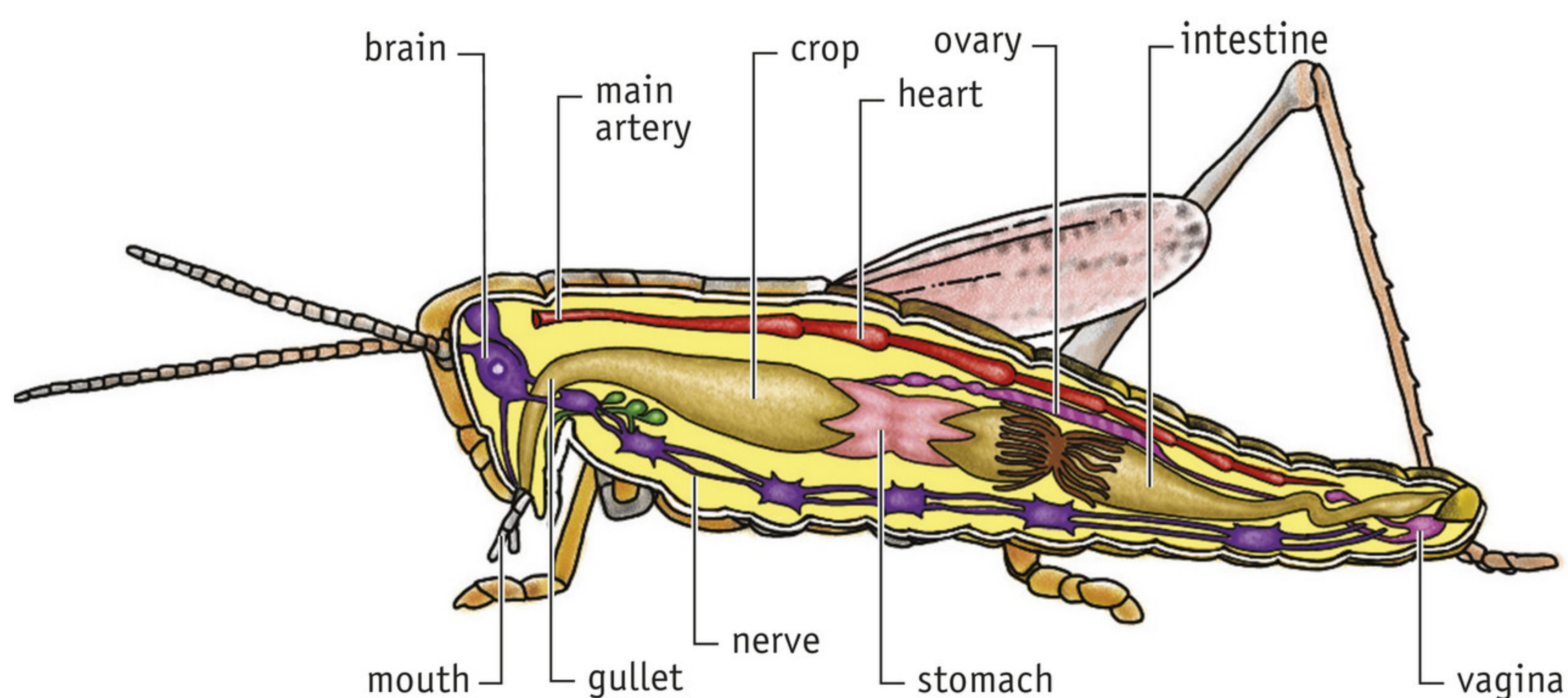
In the basics, you learned that a human body is made up of organ systems and organs. An insect's body looks very different to the body of a human. In this extension, you will learn that an insect is also made up of organ systems and organs. You have to draw the organ systems in an insect.

WB EXERCISE 1, PAGE 94

▼ **Fig. 50** Grasshopper.



1 external view



2 longitudinal section

4

Classification



BASICS

- 1 Classifying organisms
- 2 The domains bacteria and archaea
- 3 The fungal kingdom
- 4 The plant kingdom
- 5 The animal kingdom
- 6 Other unicellular eukaryotes
- 7 Classifying into smaller groups
- 8 The arthropod phylum
- 9 The vertebrate phylum
- 10 Identifying organisms
- 11 Animal project

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- 12 Classifying seed-bearing plants 151
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- 2 Live fish food 168



This unit is called 'Classification'. Classification means dividing a collection of things into groups. This gives you a better overview of the collection.

Large collections of things need to be classified. A library contains a large collection of books, for example. If all these books were not classified on the shelves, it could be almost impossible to find a particular one.

More than 1.5 million different kinds (species) of organisms have been identified. To get a good overview, the different species are classified. This unit explains how this is done.

When you read the basics, you will come across the exercises as you go. You should do the exercises in your workbook.

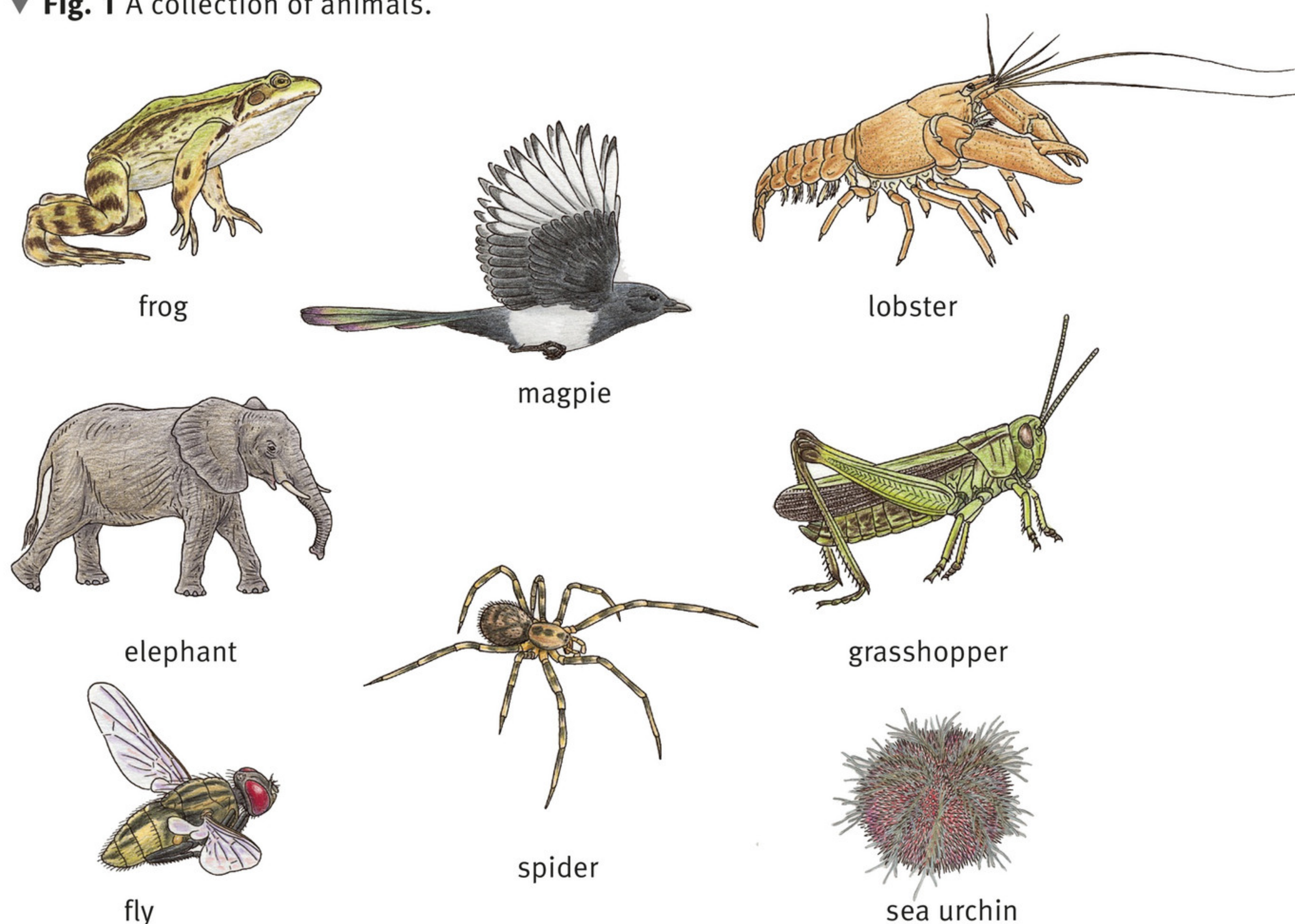
1 Classifying organisms

When you go to school, you take a collection of writing tools with you. You could classify these writing tools as ball-points, pencils, felt pens, and so forth. Or you could classify them by colour: all the red ones together, all the blue ones, and so forth. The colour is a characteristic of the writing tool. When you classify a collection, you put items with the same **characteristic** or feature into groups together.

You can classify a collection of animals (see figure 1) in various different ways. In exercise 1, you will practice classifying things. You will be doing this exercise together with the pupil next to you.

WB EXERCISE 1, PAGE 96

▼ Fig. 1 A collection of animals.

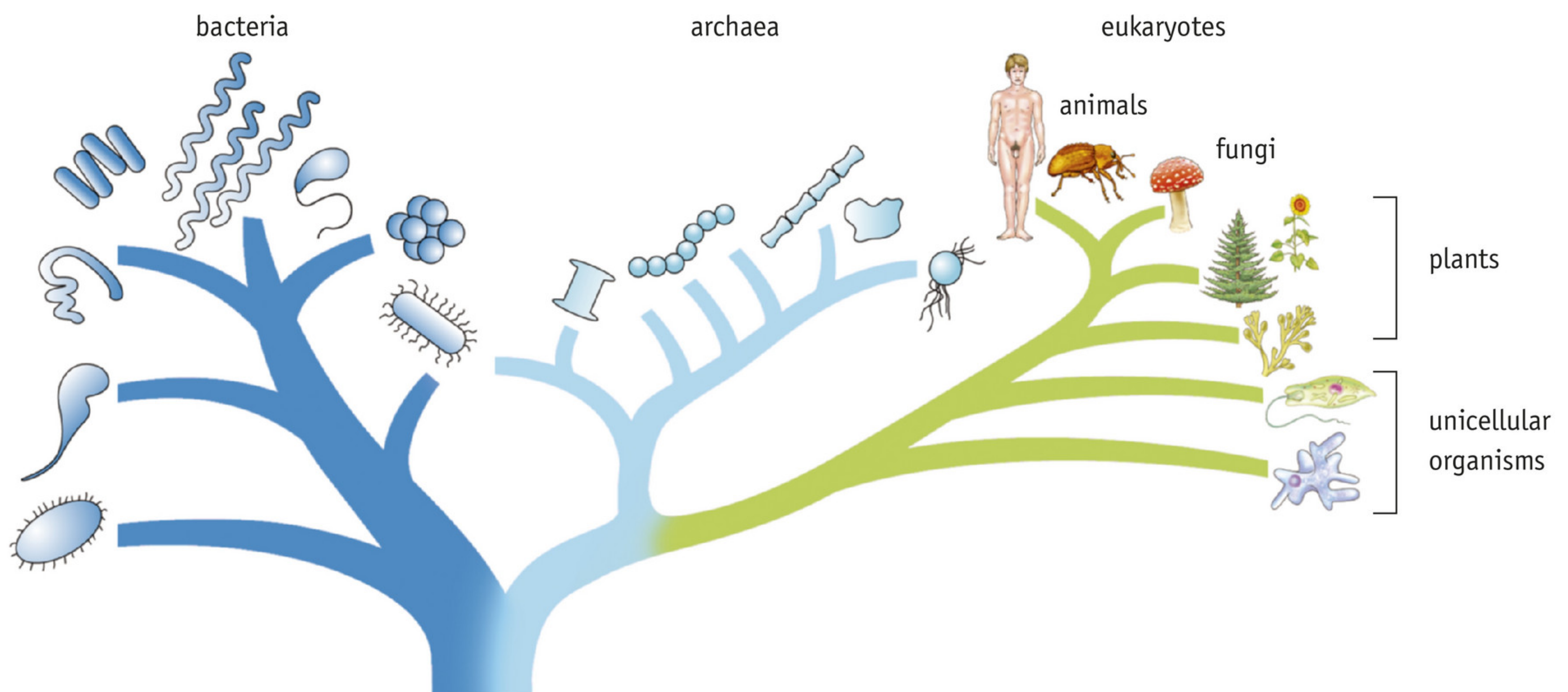


CLASSIFICATION INTO DOMAINS AND KINGDOMS

In exercise 1, you used characteristics to classify a collection of eight animals. Biologists use the characteristics of cells for classifying organisms. In addition, biologists nowadays compare **DNA** from cells to help categorise organisms. The first large groupings that are obtained when all organisms are classified are known as the **domains**. There are three domains: **bacteria**, **archaea** and **eukaryotes** (see figure 2).

Archaea seem to be like bacteria, but are nevertheless a separate group. Bacteria and archaea are called **prokaryotes**. The domains are then further subdivided into the **kingdoms**. The eukaryote domain is subdivided into the kingdoms of **fungi**, **plants** and **animals**. Biologists include humans in the animal kingdom. The classification of organisms has not yet been completed. Not all organisms have been assigned their proper place.

▼ **Fig. 2** Branching tree of all organisms.



USING CELL CHARACTERISTICS FOR CLASSIFICATION

Characteristics of cells are used when classifying organisms into domains and kingdoms. The features used are the **cell nuclei**, the **cell walls** and the **chloroplasts**.

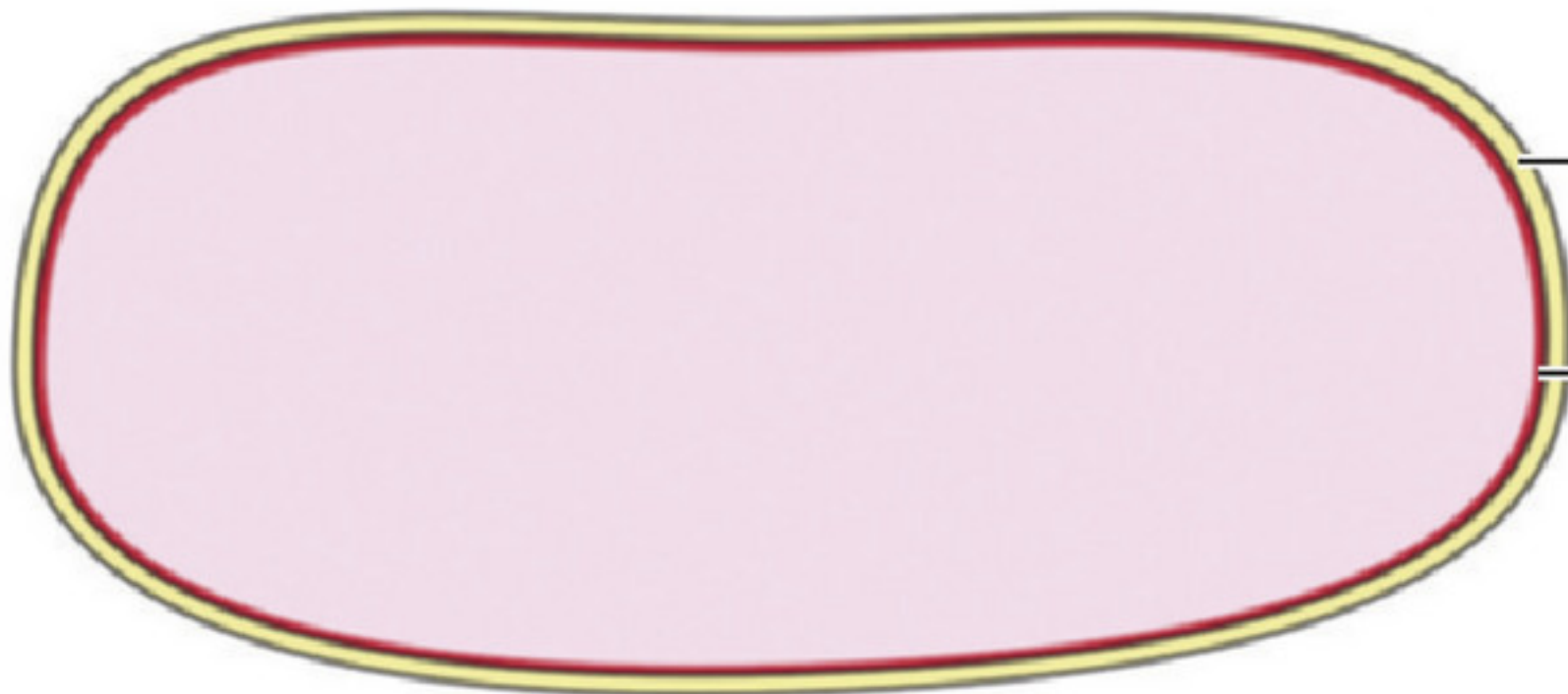
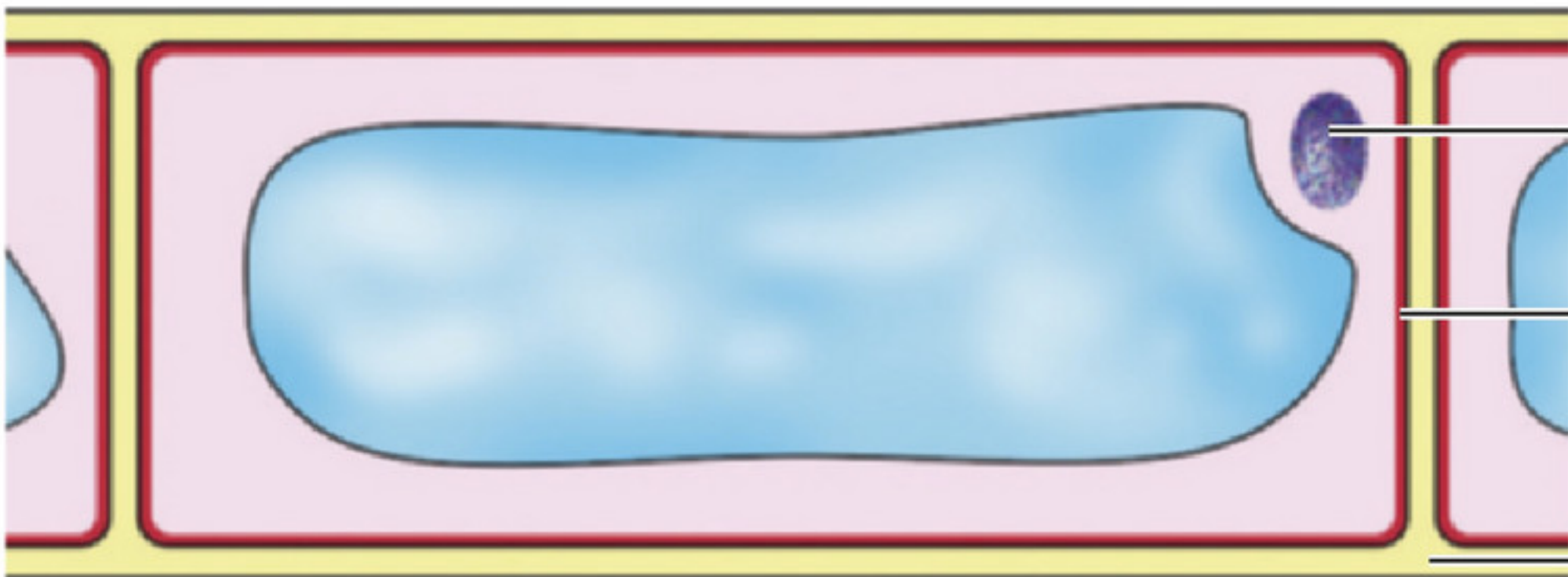
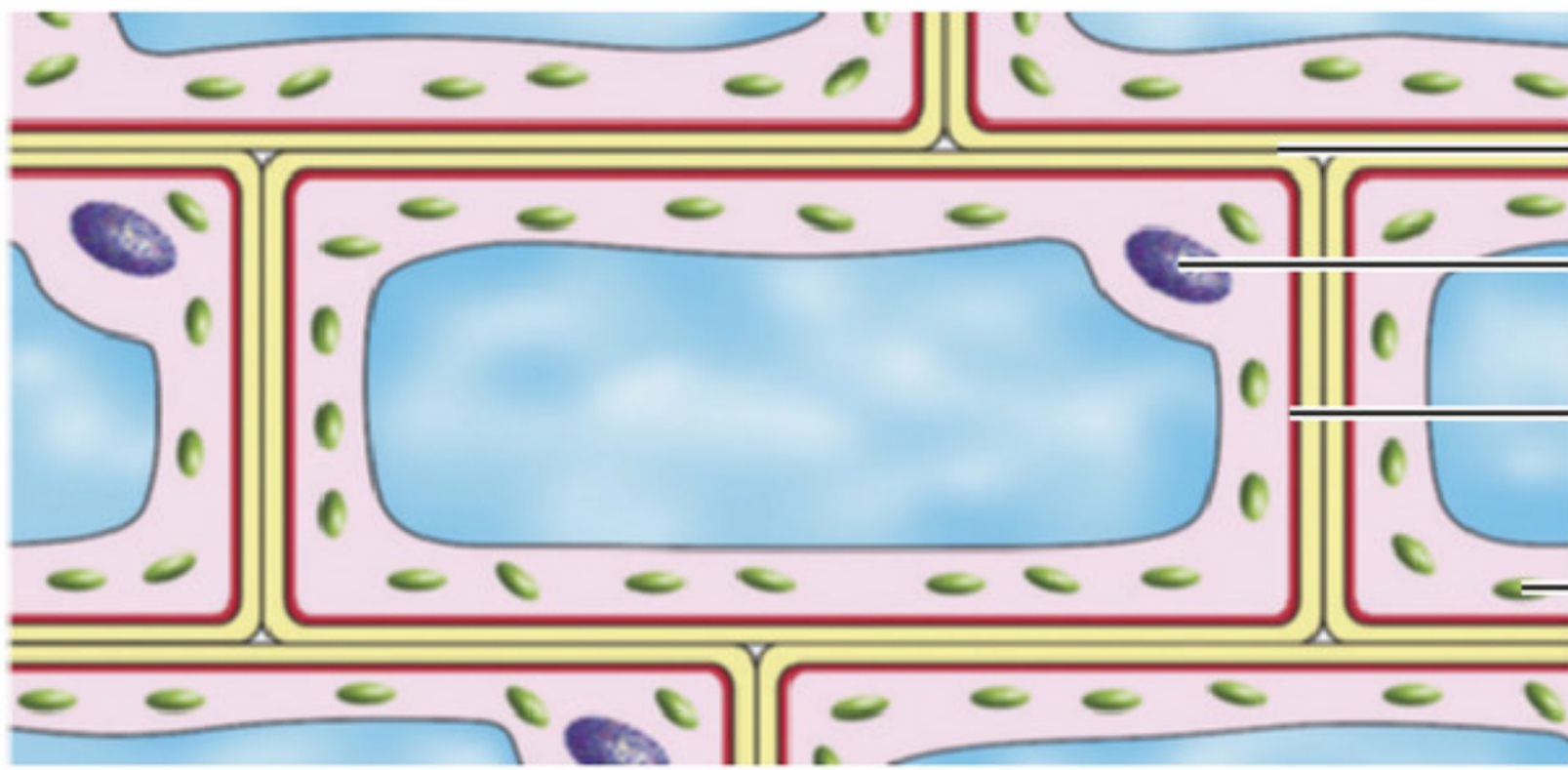
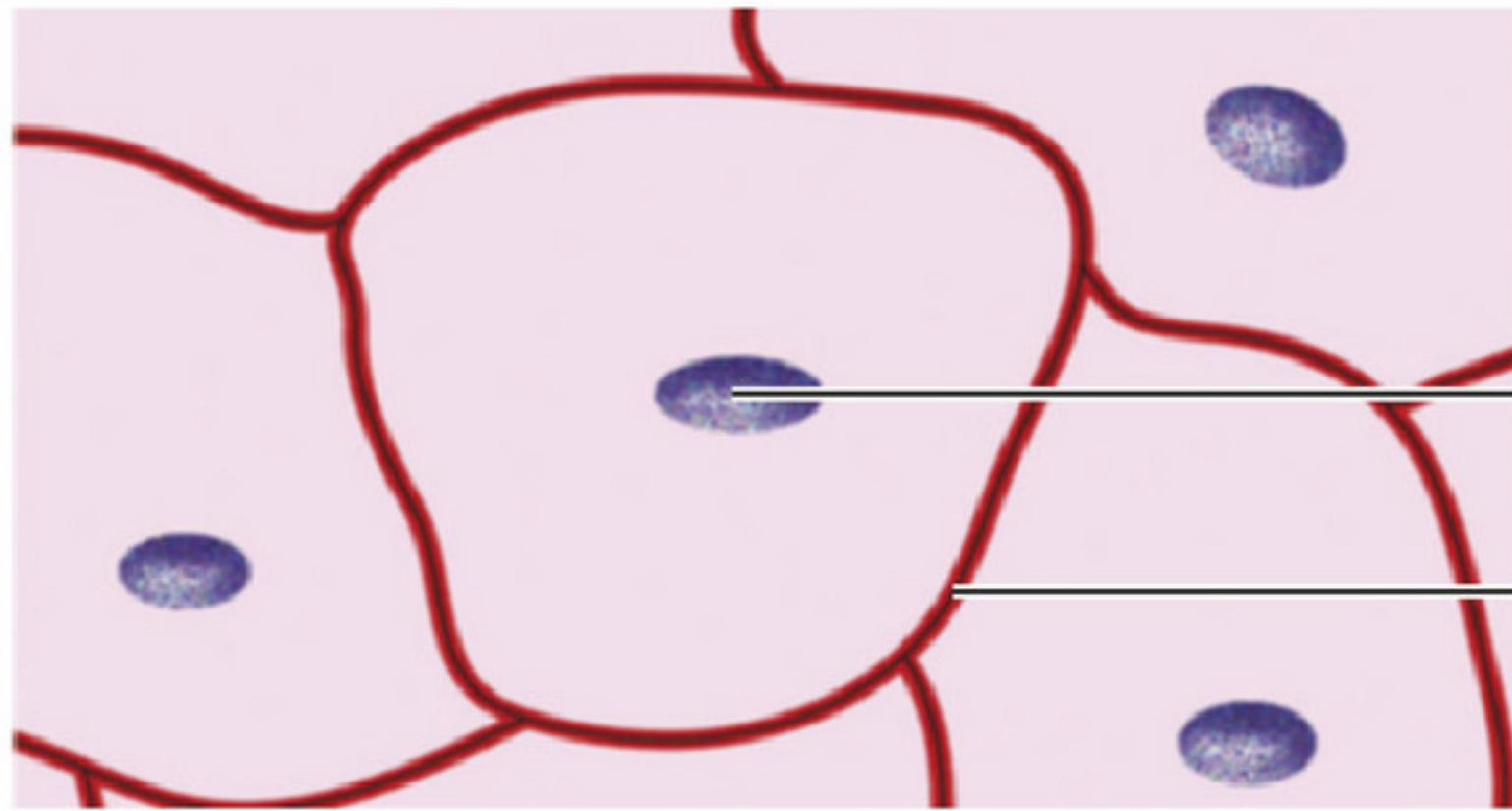
Bacteria and archaea are different from all other organisms because they have **no nucleus**. The eukaryotic cells of fungi, plants and animals contain distinct cell nuclei (see figure 3). Bacteria and archaea are always **unicellular**: they consist of a single small cell. An organism can also be made up of lots of cells. The word for that is **multicellular**. Multicellular organisms mostly consist of huge numbers of cells. A human has many billions of cells, for example. Eukaryotes can be unicellular (single-celled) or multicellular.

Animals are different from all other organisms in having **no cell walls** around their cells. Bacteria, fungi and plants do have cell walls around their cells (see figure 3).

In plants, the cytoplasm of many cells contains **chloroplasts** (see figure 3). Bacteria, fungi and animals do not have chloroplasts. In Unit 3 (Organs and cells), you learned that **photosynthesis** takes place in chloroplasts.

WB EXERCISES 2 TO 4, PAGE 96

▼ **Fig. 3** Cell characteristics of domains and kingdoms.

KINGDOM	EXAMPLE	CELL CHARACTERISTICS
BACTERIA AND ARCHAEA		 cell wall cell membrane always unicellular
EUKARYOTES	The fungal kingdom	  nucleus cell membrane cell wall unicellular or multicellular
	The plant kingdom	  cell wall nucleus cell membrane chloroplast unicellular or multicellular
	The animal kingdom	  nucleus cell membrane unicellular or multicellular

SPECIES AND BREEDS

Organisms that look a great deal like one another do not have to belong to the same species. An African elephant and an Indian elephant look very like each other (see figure 4), but they are not the same species.

▼ **Fig. 4** Two different species of elephant.



1 African elephant

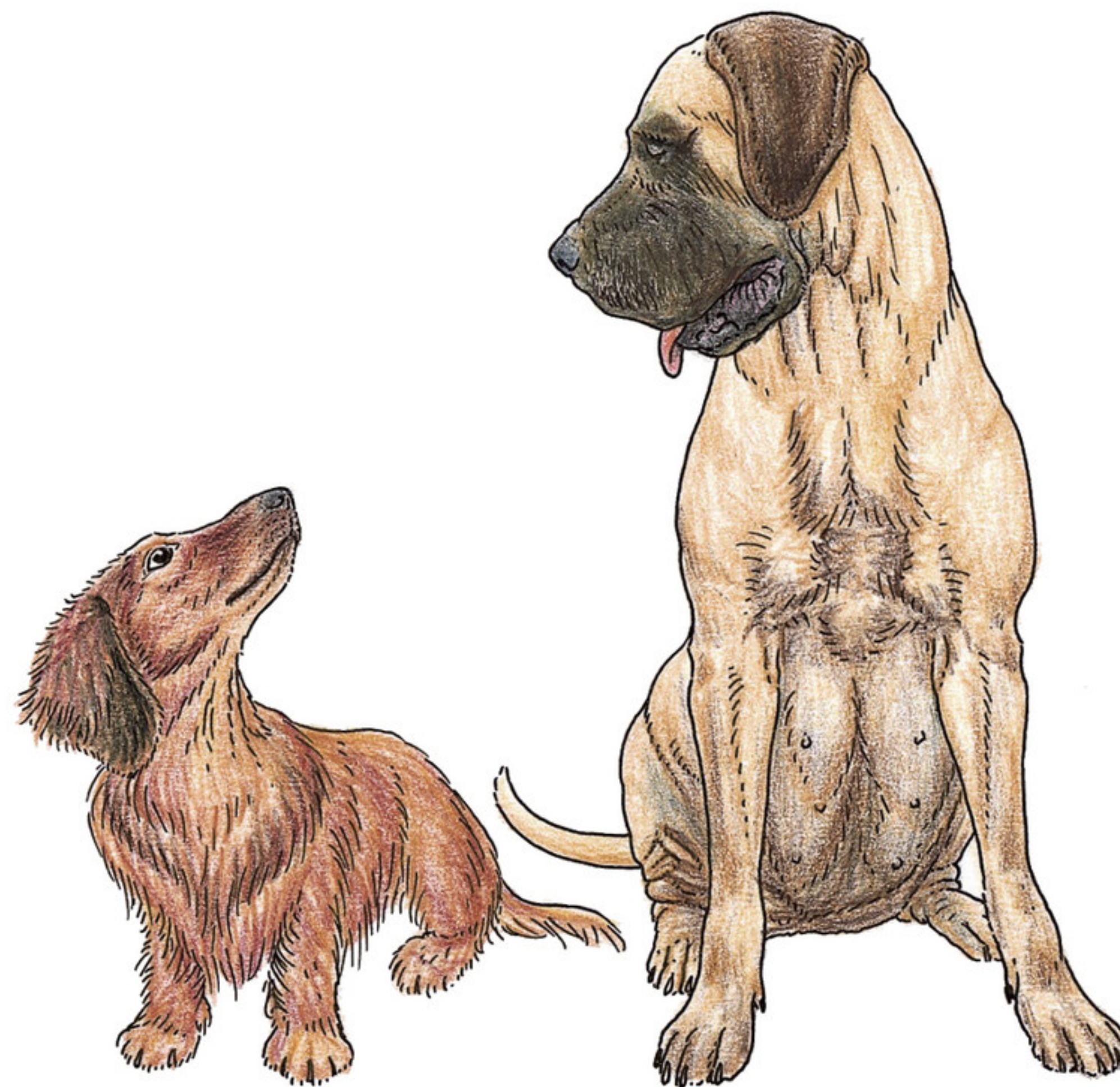


2 Indian elephant

A miniature Dachshund and a Great Dane (see figure 5) look much less alike than the elephants, but they do belong to a single species. They are two different **breeds** of the dog species.

Organisms belong to the same species if they are capable of reproducing together. The offspring that they then have must also be able to reproduce. In other words, the offspring must be **fertile**.

▼ **Fig. 5** Two breeds of the same species.



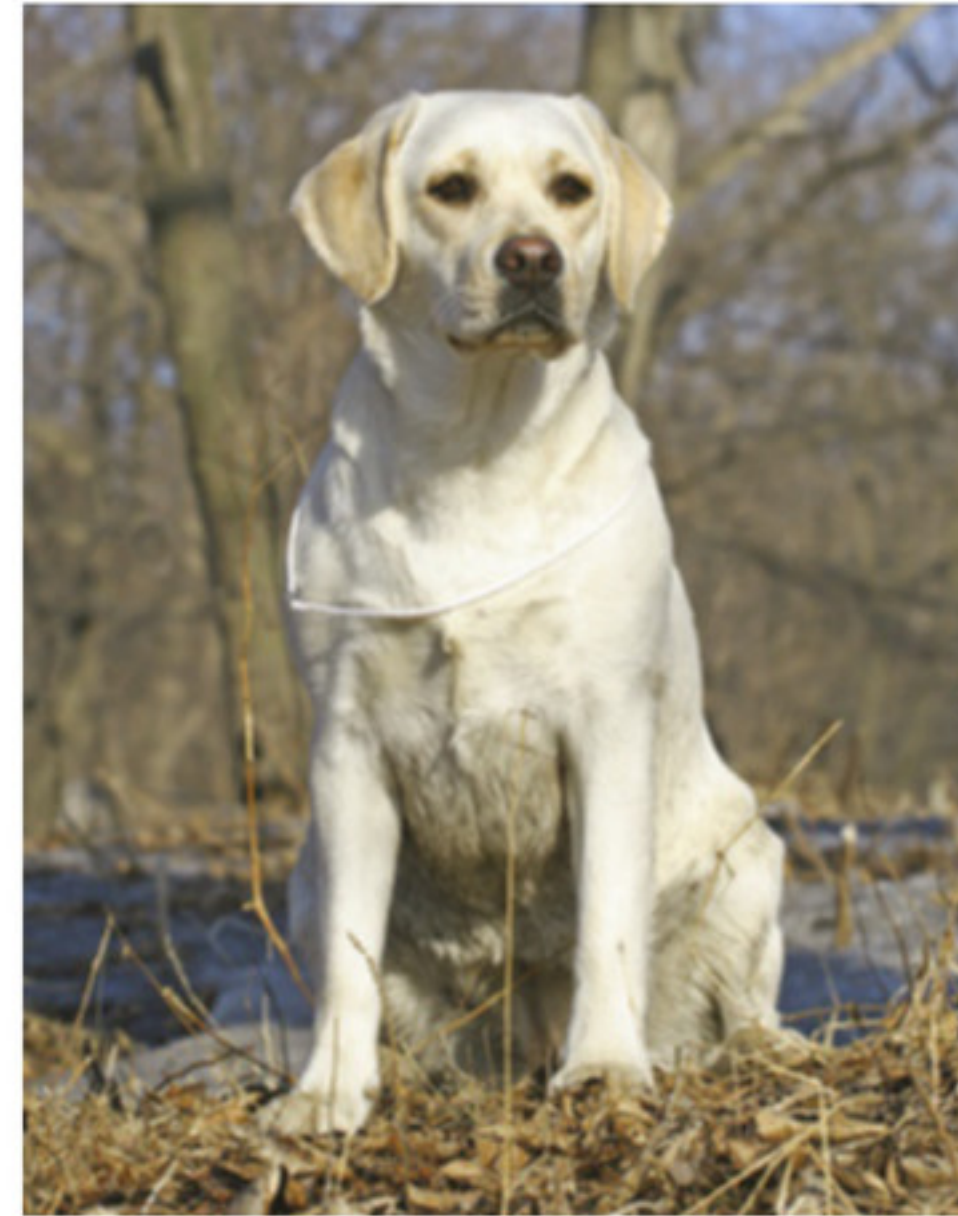
1 miniature Dachshund

2 Great Dane

African and Indian elephants cannot reproduce together. A miniature Dachshund and a Great Dane could. Not that a miniature Dachshund is likely to mount a Great Dane. But other breeds of dog do often mate and produce fertile offspring (see figure 6).

Organisms belong to a single species if they are able to have fertile offspring together.

▼ **Fig. 6** A Labrador and a poodle can have fertile offspring.



1 Labrador



2 poodle



3 offspring ('labradoodle') that is fertile

WB EXERCISE 5, PAGE 98

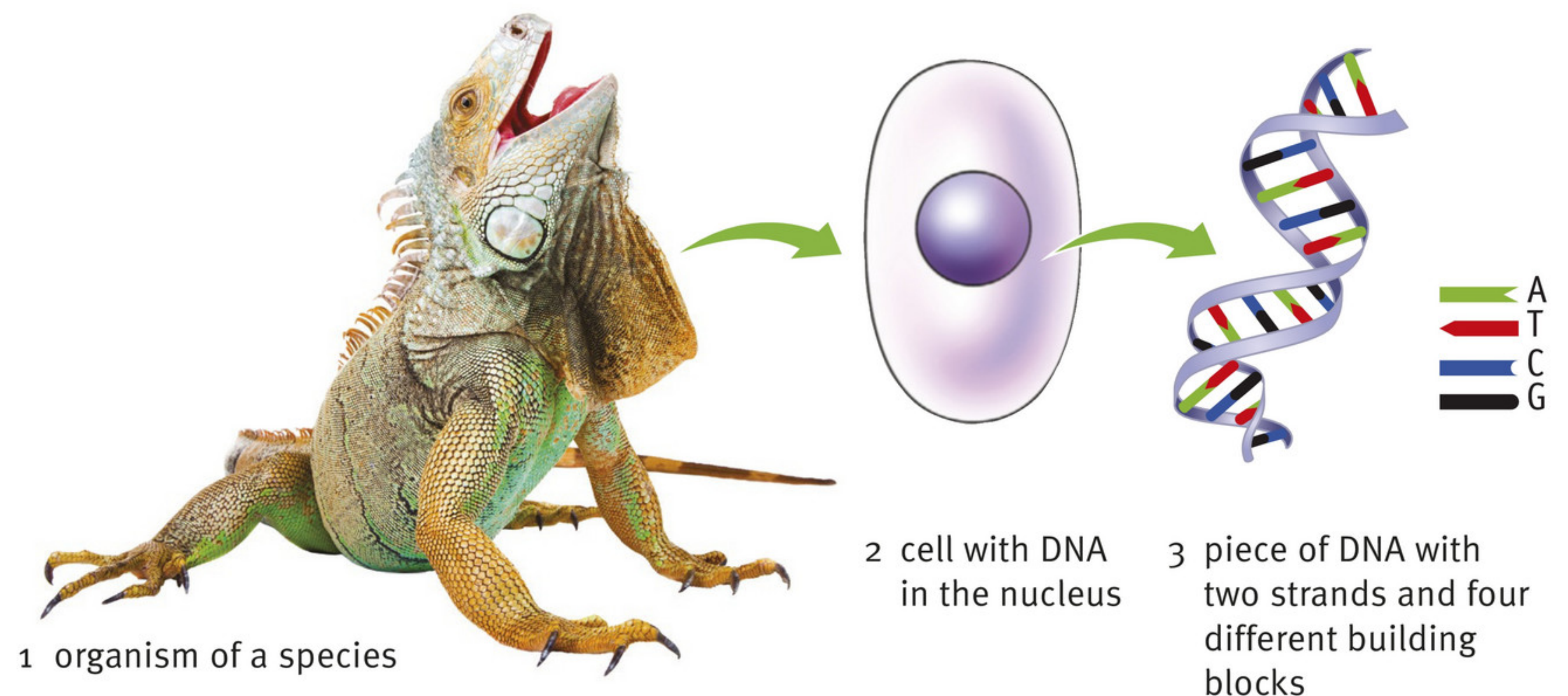
COMPARING DNA BETWEEN DIFFERENT SPECIES

In Unit 3 (Organs and cells), you learned that the DNA in organisms' cells is made up of four building blocks. These building blocks are in a specific sequence for each species. This means that every species has its own DNA sequence (see figure 7). The DNA of organisms that belong to the same species is always very similar. Even so, there are very small differences between the DNA of organisms of a single species. The sequence of the four building blocks of DNA can differ a little bit between organisms of the same species.

Biologists are trying to collect data on the same region of DNA from all species (see figure 8). The DNA from different groups of organisms can then be compared with one another. Comparative DNA studies can then show whether two groups of organisms belong to the same species or not.

WB EXERCISES 6 AND 7, PAGE 99

▼ **Fig. 7** Each species has its own unique DNA.



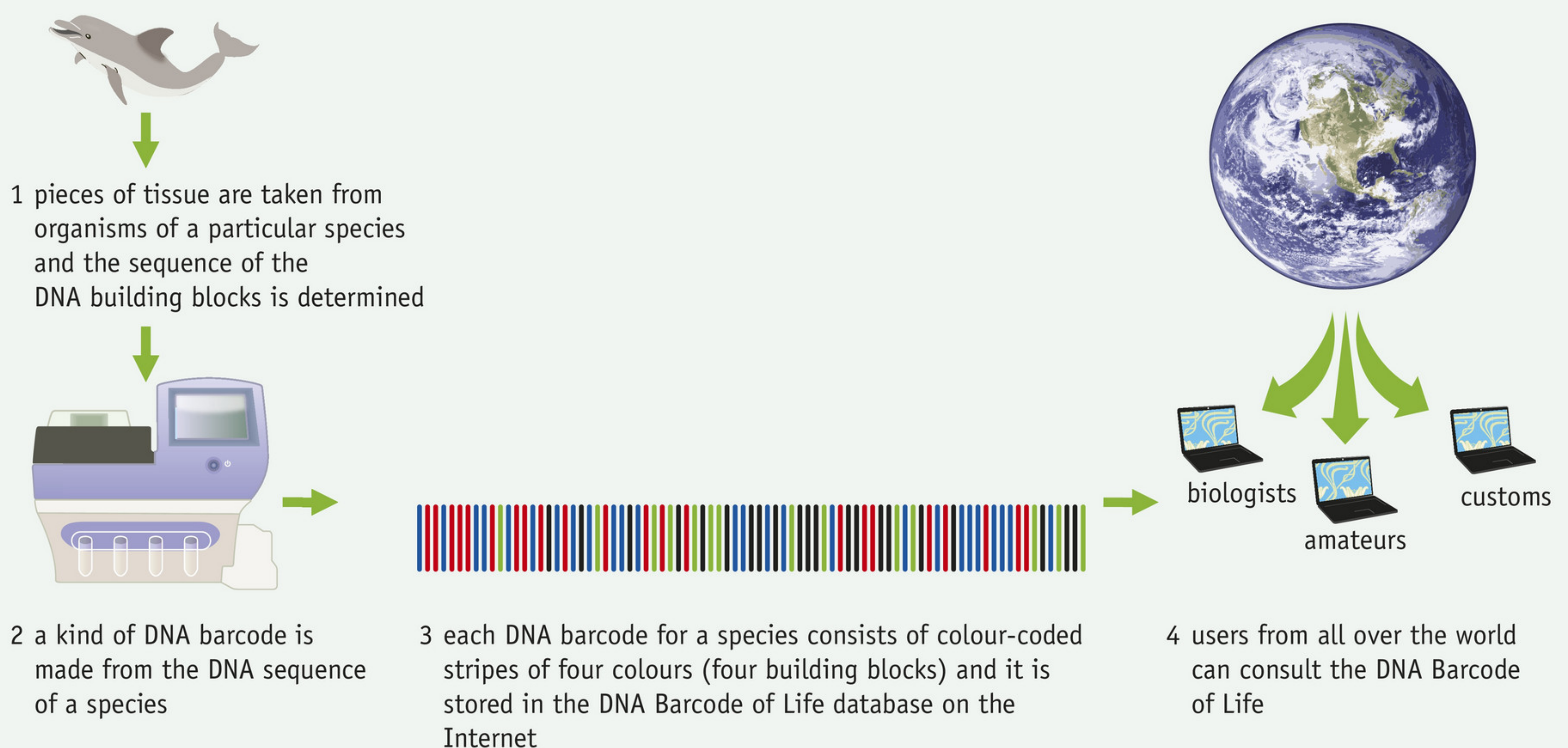
▼ Fig. 8

Molecular biologist

Biologists throughout the world are attempting to collect data on the DNA of all organisms. This research is called the DNA Barcode of Life. Analysing the DNA of an organism is getting faster and cheaper. For each domain or kingdom, people are trying to investigate a fixed piece of DNA. The pictures show you how this is done.

Kevin Beentjes is a researcher at Naturalis in Leiden. He is working on DNA barcodes of plant, animal and fungal species in the Netherlands. Currently, the DNA barcode of an organism is still determined in the laboratory, where it can take a couple of days for the DNA barcode to be worked out. DNA barcoding can be very useful for resolving questions about organisms that are difficult or impossible to recognise. Examples could be a market gardener with some kind of pest affecting his crop, boots of exotic leather that have been intercepted by the customs authorities, or fungi on food. In the future,

it may be possible to determine DNA barcodes with a scanner device, so that answers to these kinds of questions can be given even more quickly.



2 The domains bacteria and archaea

You have learned that **bacteria** and **archaea** are called prokaryotes. These are **unicellular** organisms with **no nucleus**. Prokaryotes are very small – so small that you can only see them as dots or lines, even with a normal microscope (see figure 9.1). To be able to study bacteria and archaea properly, you need an electron microscope (see figure 9.2). This type of microscope can magnify up to several hundred thousand times.

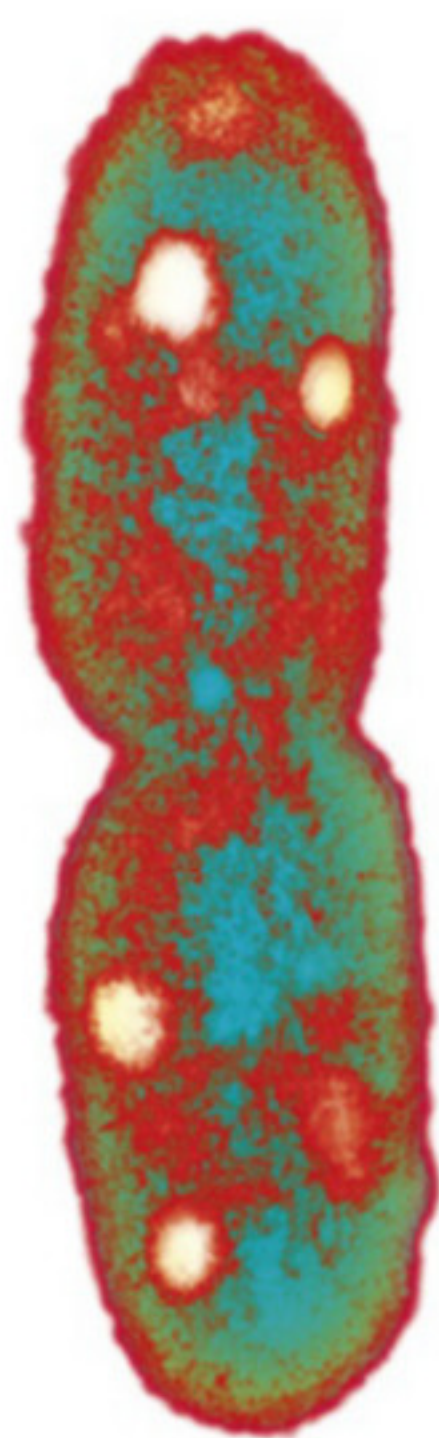
► **Fig. 9** This is what bacteria look like.



1 under a normal microscope

2 under an electron microscope

▼ **Fig. 10** A bacterium dividing (electron microscope photo at 40,000× magnification).



REPRODUCTION OF PROKARYOTES

Bacteria and archaea reproduce by **division** (also known as ‘binary fission’). This then produces two smaller cells (see figure 10). These then grow until they are just as big as the original cell. Prokaryotes can reproduce very quickly. Under favourable conditions, some bacteria can divide every half hour.

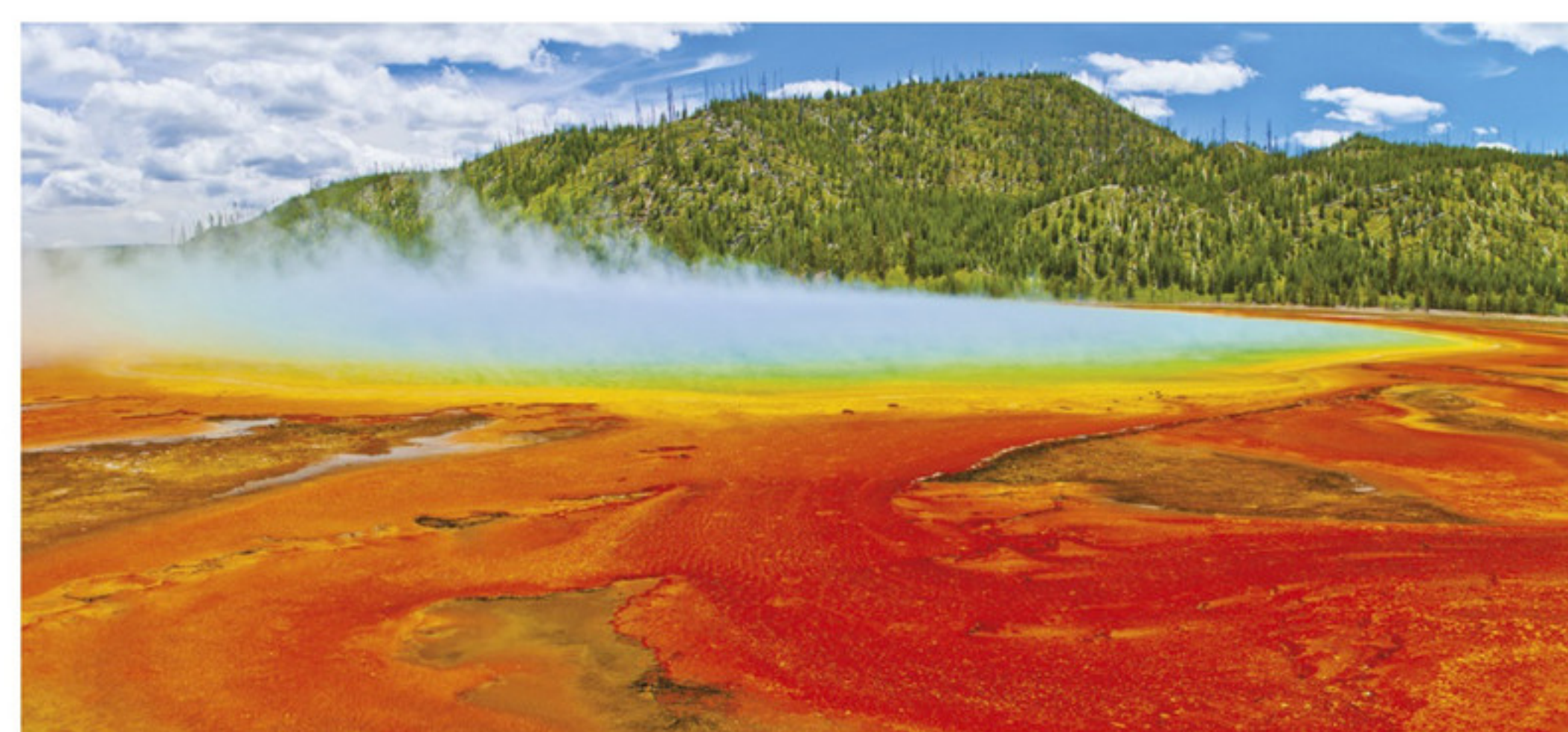
THE DOMAIN ARCHAEA

There are huge numbers of different kinds of bacteria, but only a few hundred species of archaea (singular: archaeon). From the outside, archaea look a lot like bacteria, but internally they also have some of the features of eukaryotic cells. The archaea are therefore a separate domain. Most of the archaea are ‘extremophiles’ (organisms that live under extreme conditions), for instance in hot springs where the acidity is high (see figure 11). The conditions in your stomach are also very acidic. There are also archaea that live in your digestive tract.

► **Fig. 11** These archaea live in hot (80°C) acidic springs in Yellowstone National Park in North America.



1 archaea



2 hot, acidic spring in Yellowstone National Park with an orange colour at the edges that is produced by bacteria

THE BACTERIAL DOMAIN

Bacteria are everywhere. There are many billions of bacteria inside your body too (see figure 12). Most types of bacteria feed on the dead residues of organisms. In nature, bacteria clear up the remains of organisms. This releases **nutrients** that can be used by plants. Special strains of bacteria are used for making some foodstuffs, for example yoghurt and sauerkraut (see figure 13).

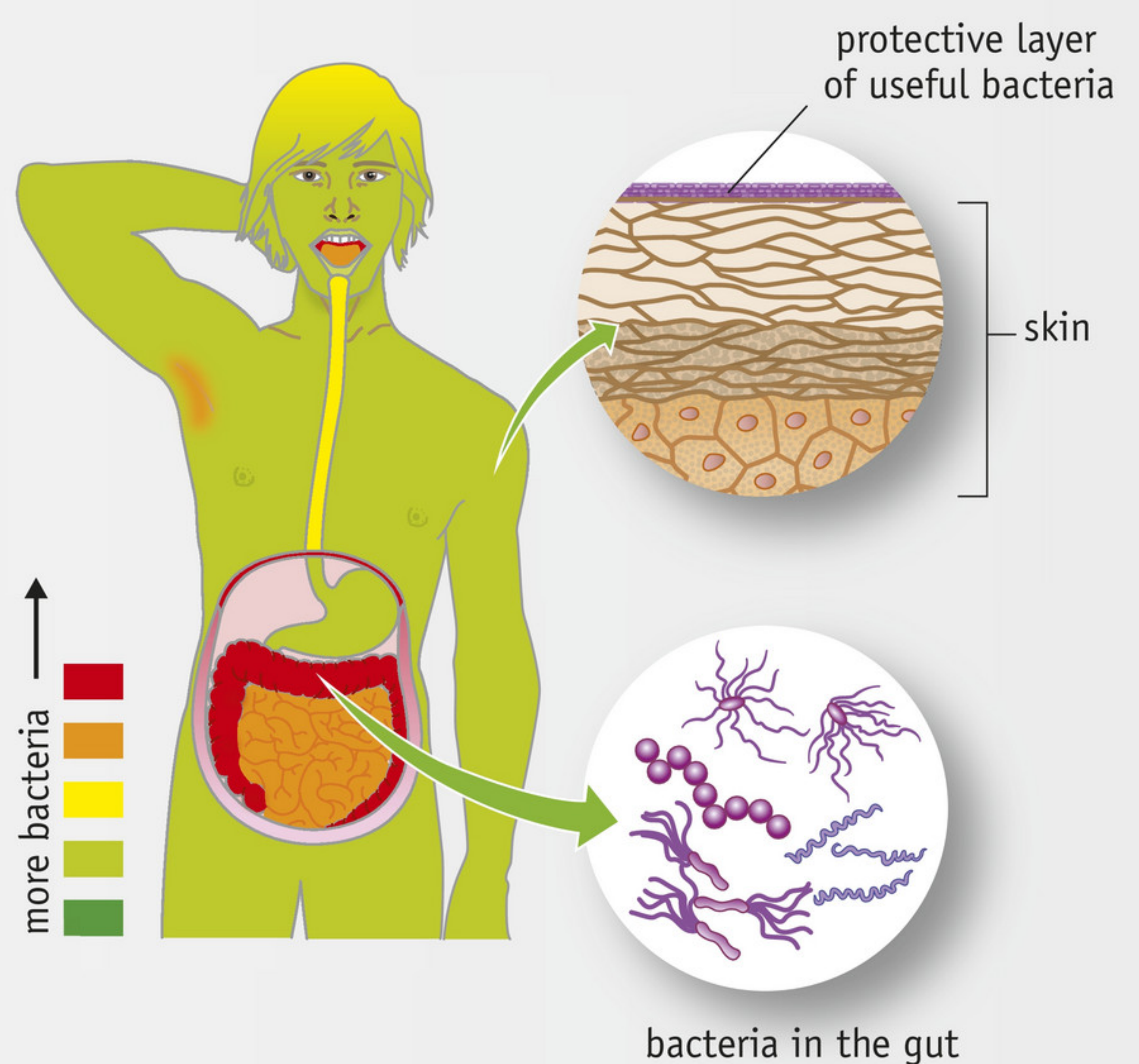
▼ Fig. 12

Humans are full of bacteria

The human body is a perfect spot for bacteria. It is warm and moist and full of food. In your mouth alone, there are about 25× as many bacteria as there are people on the entire planet. And there are far more bacteria than that in the intestines. The numbers are mind-boggling. Fortunately, the vast majority of them are useful to humans. The bacteria in your intestines help pre-digest food. If you had no bacteria in your intestines, you would get a great deal thinner.

Because large numbers of useful bacteria live in your body, it is difficult for harmful ones to find a spot. But sometimes they do, and you may then get ill.

There is also a protective layer of useful bacteria on your skin (see the picture). In addition to bacteria, there are small numbers of single-celled eukaryotes and archaea in your intestines. The archaea in the gut are unusual because they produce the gases that leave your body as wind.



► Fig. 13 Yoghurt and sauerkraut.



As well as lots of useful species of bacteria, there are also harmful ones that can get inside your body and cause diseases. This is known as an **infection**. Examples of these **bacterial infections** are cholera, pneumonia, ear infections, tuberculosis and bladder infections (see figure 14). Bacterial infections can be tackled with **antibiotics** (see figure 15), such as penicillin. These are medicines that kill the bacteria in the body. An **antibiotic** generally cures bacterial infections quickly. Our food also often consists of the (dead) remains of organisms, for example fruit or vegetables or meat. Bacteria can live on this perfectly well. This is why food can go bad (see figure 16).

▼ Fig. 14

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Medical microbiology technician

Hello. I'm Noa. I work as a medical microbiology technician at a hospital. In our laboratory, I look to see whether there are bacteria in urine samples, for instance. You cannot see individual bacteria with the naked eye. As they divide, though, this creates bacterial colonies that you can see. I use an inoculating needle to put a tiny bit of urine on a culture medium in a Petri dish, and then leave it in an incubator at 37°C. Bacteria grow well on this kind of medium. If there are any bacteria in the urine, they will multiply rapidly. After about 24 to 48 hours in the incubator, each bacterium on the culture medium will have grown into a bacterial colony. Bacterial colonies are visible to the naked eye. If bacteria can be found in the urine sample on the culture medium, it usually means that the patient has a bladder infection. The doctor will then prescribe medicine for it.



▼ Fig. 15 Antibiotics.



▼ Fig. 16 Sometimes you can easily see when food has gone bad.

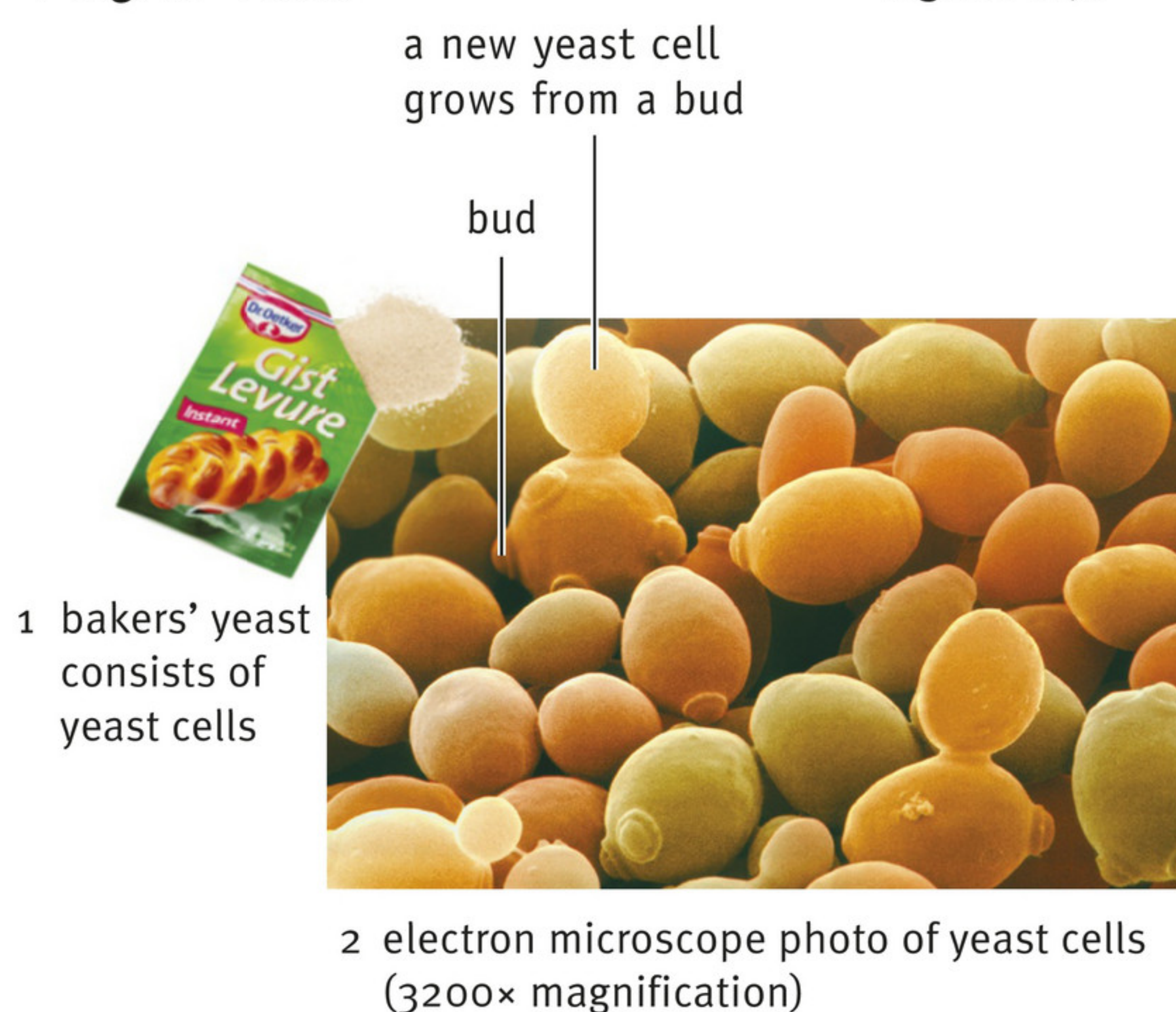


3 The fungal kingdom

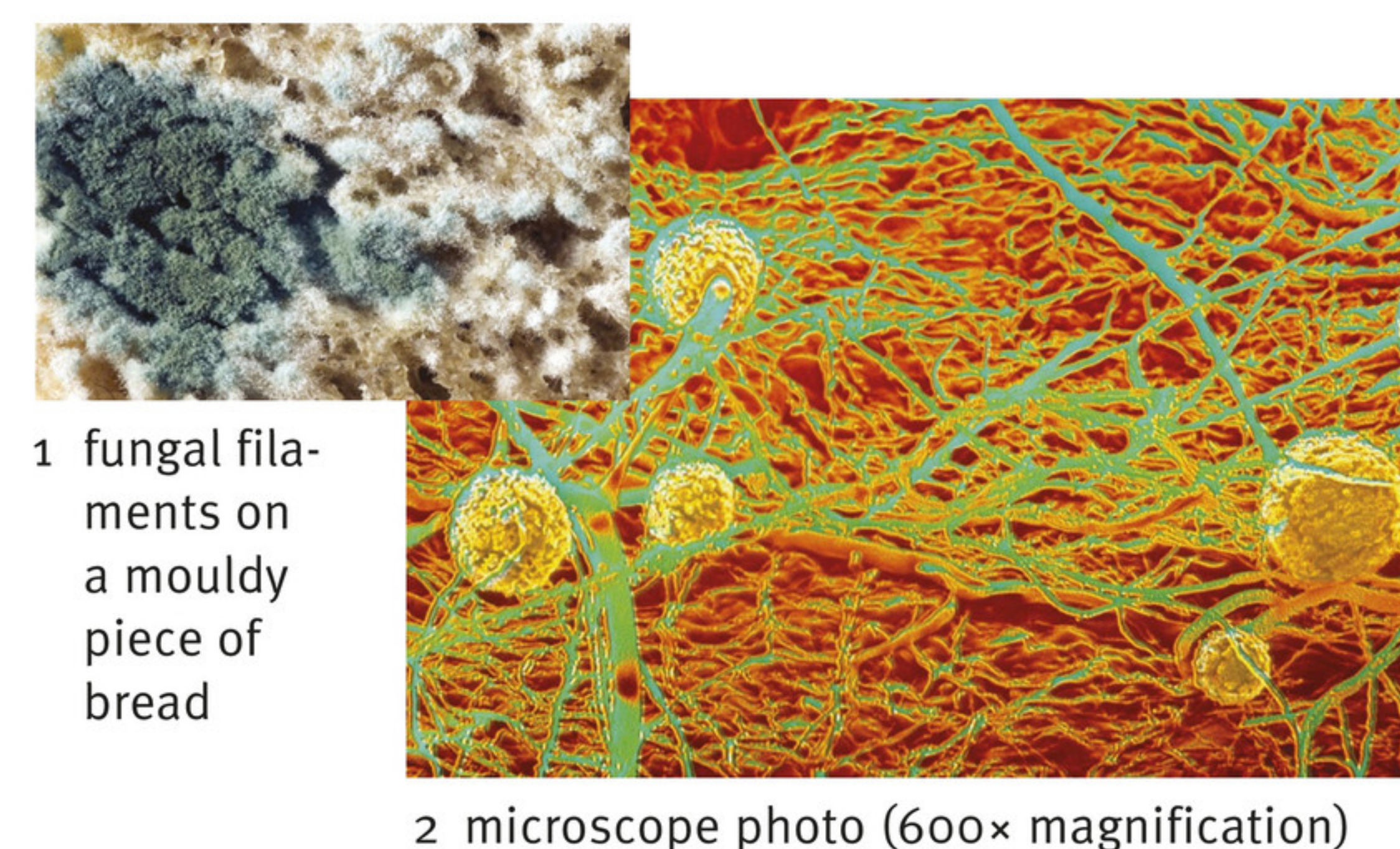
Fungi can be **unicellular** or **multicellular**. **Yeasts** are unicellular fungi (see figure 17).

Multicellular fungi generally form long, thin filaments called **hyphae** (singular: hypha). You can find these on a mouldy piece of bread, for instance (see figure 18).

▼ **Fig. 17** Yeast.



▼ **Fig. 18** Fungal filaments (hyphae).

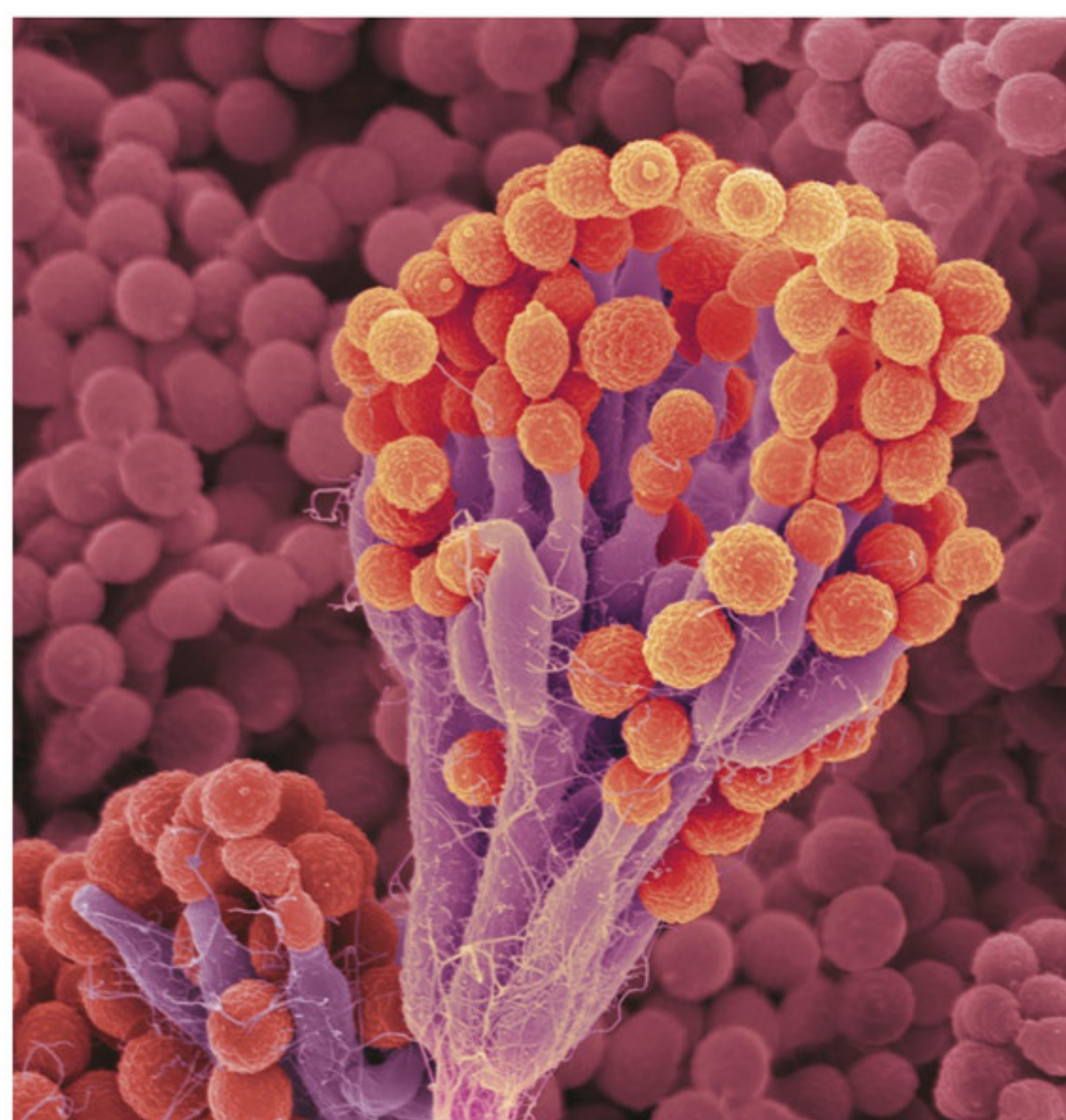


REPRODUCTION

Yeasts reproduce by division. Yeast cells that are dividing produce a **bud**. This bud grows into a new yeast cell (see figure 17).

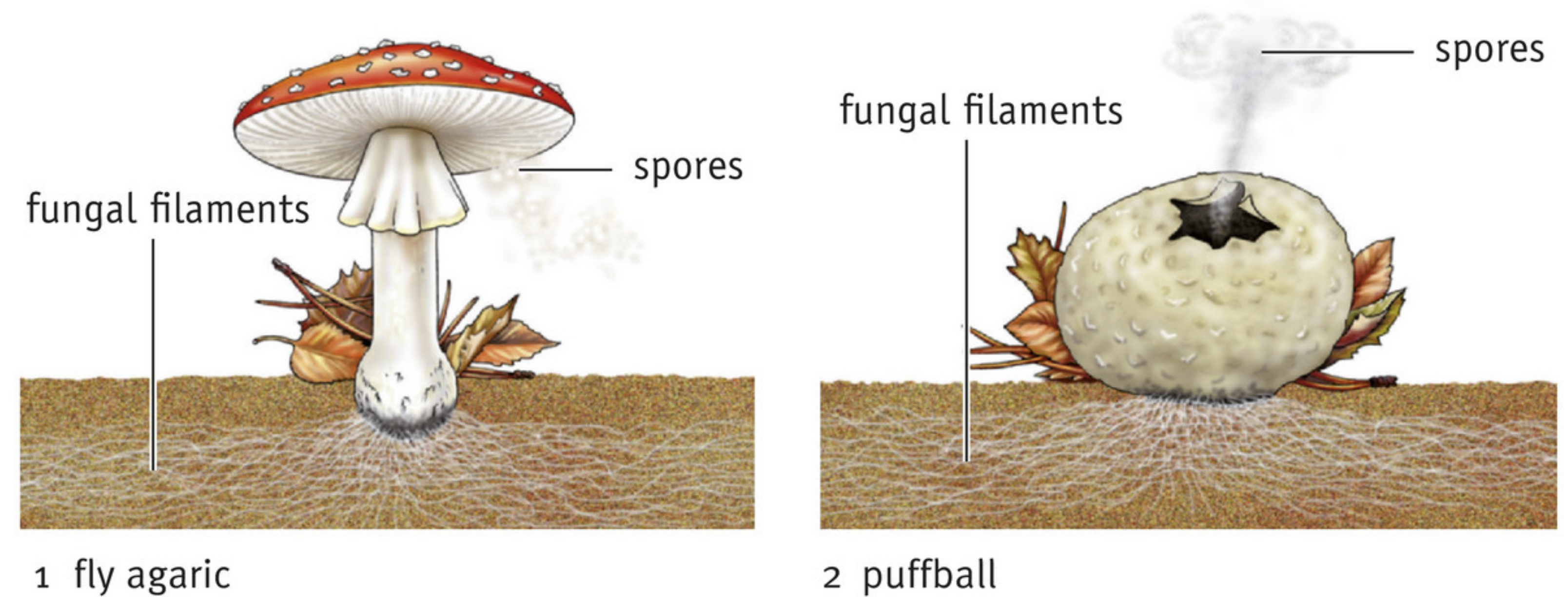
Multicellular fungi mostly reproduce through **spores**. Spores are cells that a new fungus can grow from. In many types of fungi, the spores appear at the ends of fungal filaments that grow upwards. This is the case in **penicillium mould**, for example (see figure 19). This is the species of mould from which the antibiotic **penicillin** is made.

► **Fig. 19** Penicillium mould (600× magnification).

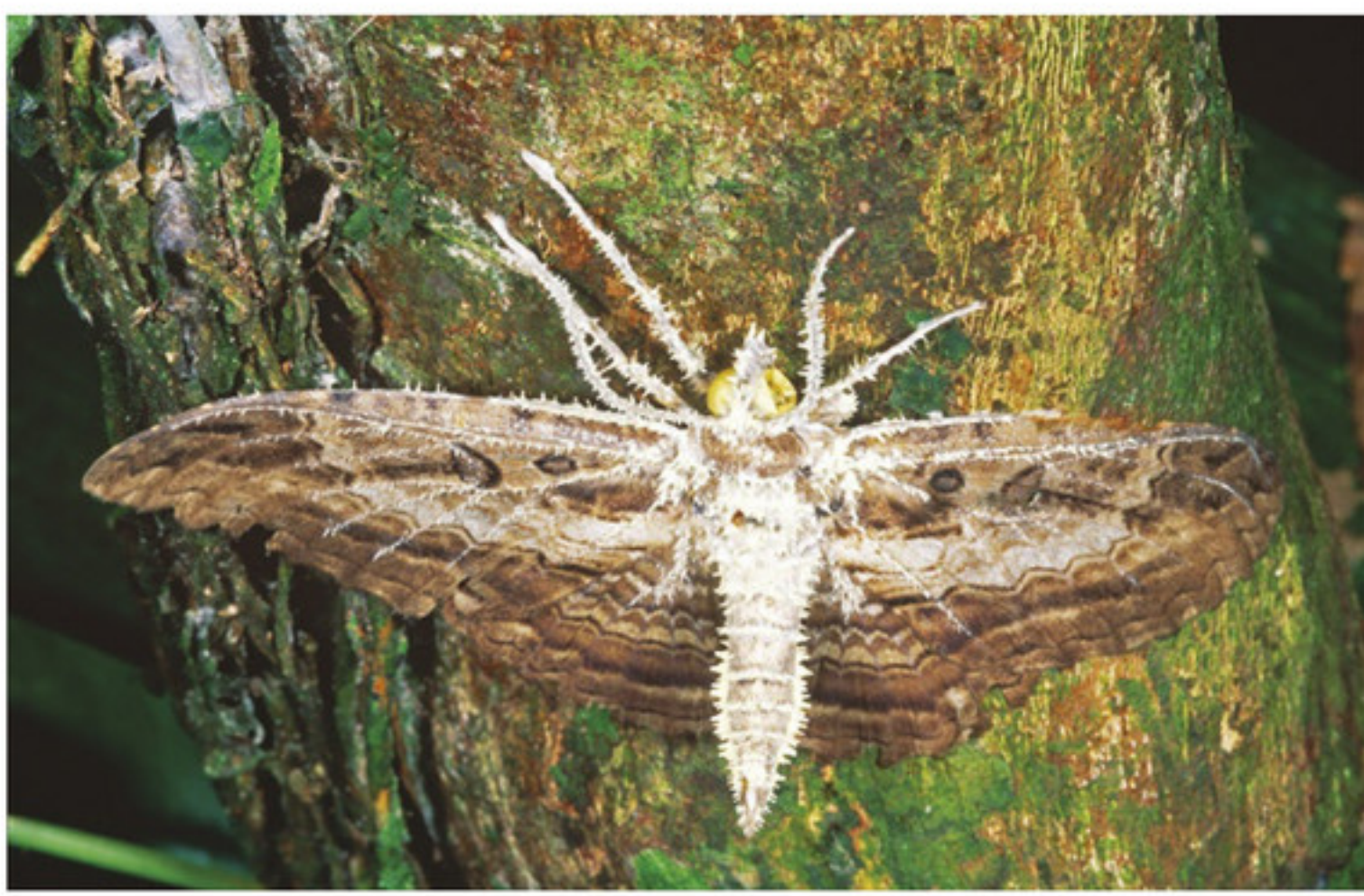


There are other types of fungi in which the spores are made in special organs: the **toadstools**. This is for instance the case in fly agaric and puffballs (see figure 20). Toadstools are involved in the reproduction of fungi.

▼ **Fig. 20** Fungi with toadstools.



▼ **Fig. 21** Fungi clear up the remains of plants and animals.



▼ **Fig. 22** Rotting food.



USEFUL AND HARMFUL FUNGI

Most types of fungus feed on the dead residues of organisms. An important function of such fungi in nature is that they clear up the remnants of dead organisms, just as bacteria do (see figure 21).

Fungi can also cause food to go off (see figure 22). In the home, moulds can be persistent residents of the bathroom (see figure 23). Some species of fungi can cause diseases in plants, animals or people. In humans, fungal infections include **athlete's foot**. In this condition, the skin between the toes becomes inflamed (see figure 24). Fungal infections can be tackled with medicines. Antibiotics can be used for some fungal infections.

▼ **Fig. 23** Spots of mould in a bathroom.



▼ **Fig. 24** Athlete's foot.



Yeasts are also used in the preparation of bread. Bakers add yeast to the dough so that it will rise (see figure 25). This makes the bread lighter. Special types of fungi are used in the preparation of foodstuffs such as bread, beer, wine and blue cheese (see figure 26).

▼ **Fig. 25** Bread dough.



1 before the yeast has had any effect

2 after the yeast has taken effect

▼ **Fig. 26** Fungi are used in preparing these foods.



In the production of wine and beer, yeasts produce the alcohol. The toadstools of some types of fungus are edible, for instance the toadstools of fungi such as mushrooms (see figure 27).

WB EXERCISES 11 TO 14, PAGE 105

▼ **Fig. 27** Edible toadstools.



4 The plant kingdom

A kingdom is subdivided further into **phyla** (singular: phylum). The three phyla in the plant kingdom are **algae**, **spore-bearing plants** and **seed-bearing plants**.

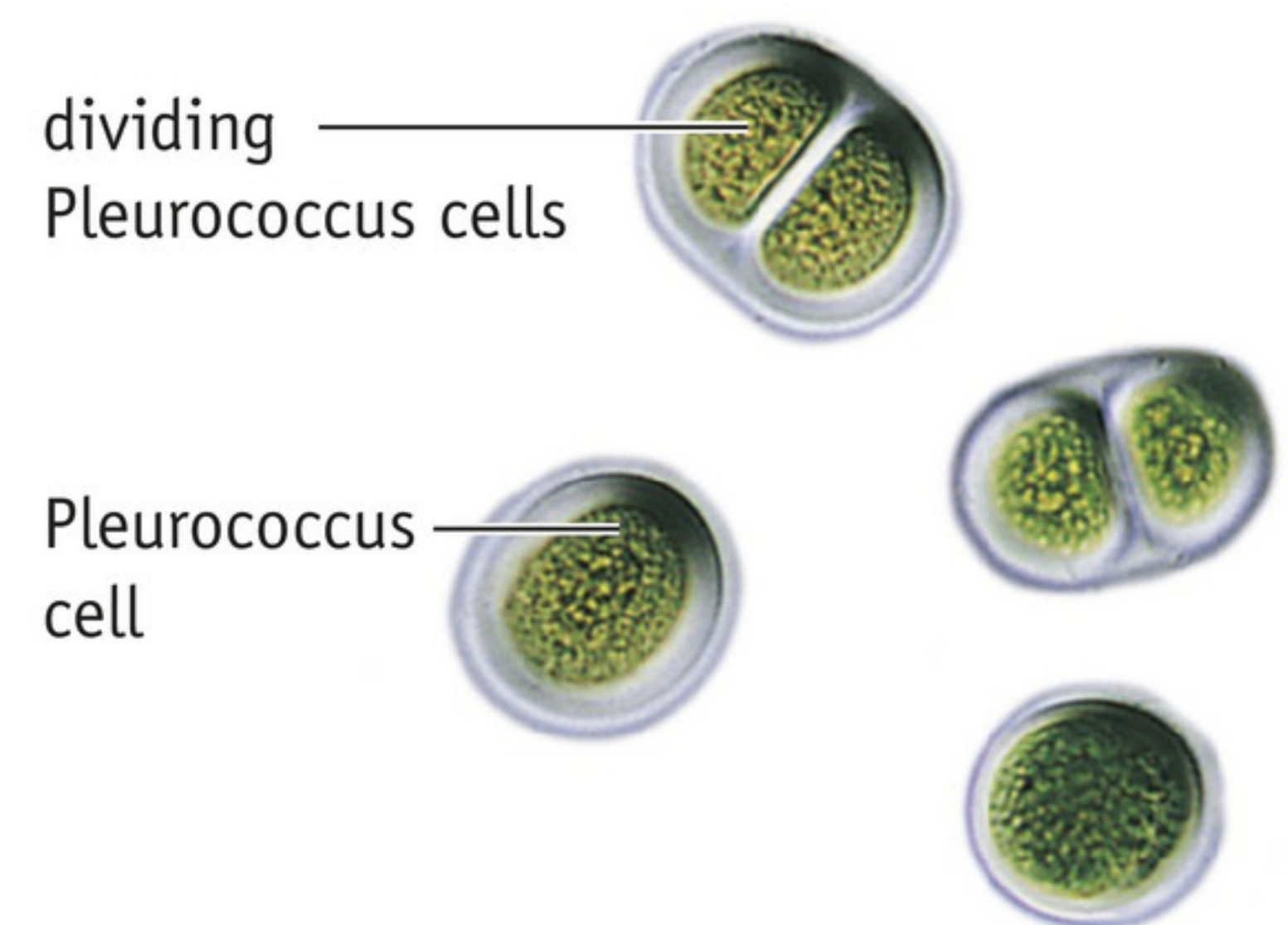
ALGAE

Most algae grow in water. **Algae** therefore have **no roots** and **no stems**. They get their minerals out of the water surrounding them. Algae also have **no leaves** and **no flowers**. There are unicellular algae and multicellular algae. **Unicellular algae** include **Pleurococcus**, a green alga that can be found in large numbers on tree trunks and on walls. Together, these algae create the green deposits that you can find on these places (see figure 28.1). Pleurococci reproduce by division (see figure 28.2).

▼ Fig. 28 Pleurococcus.



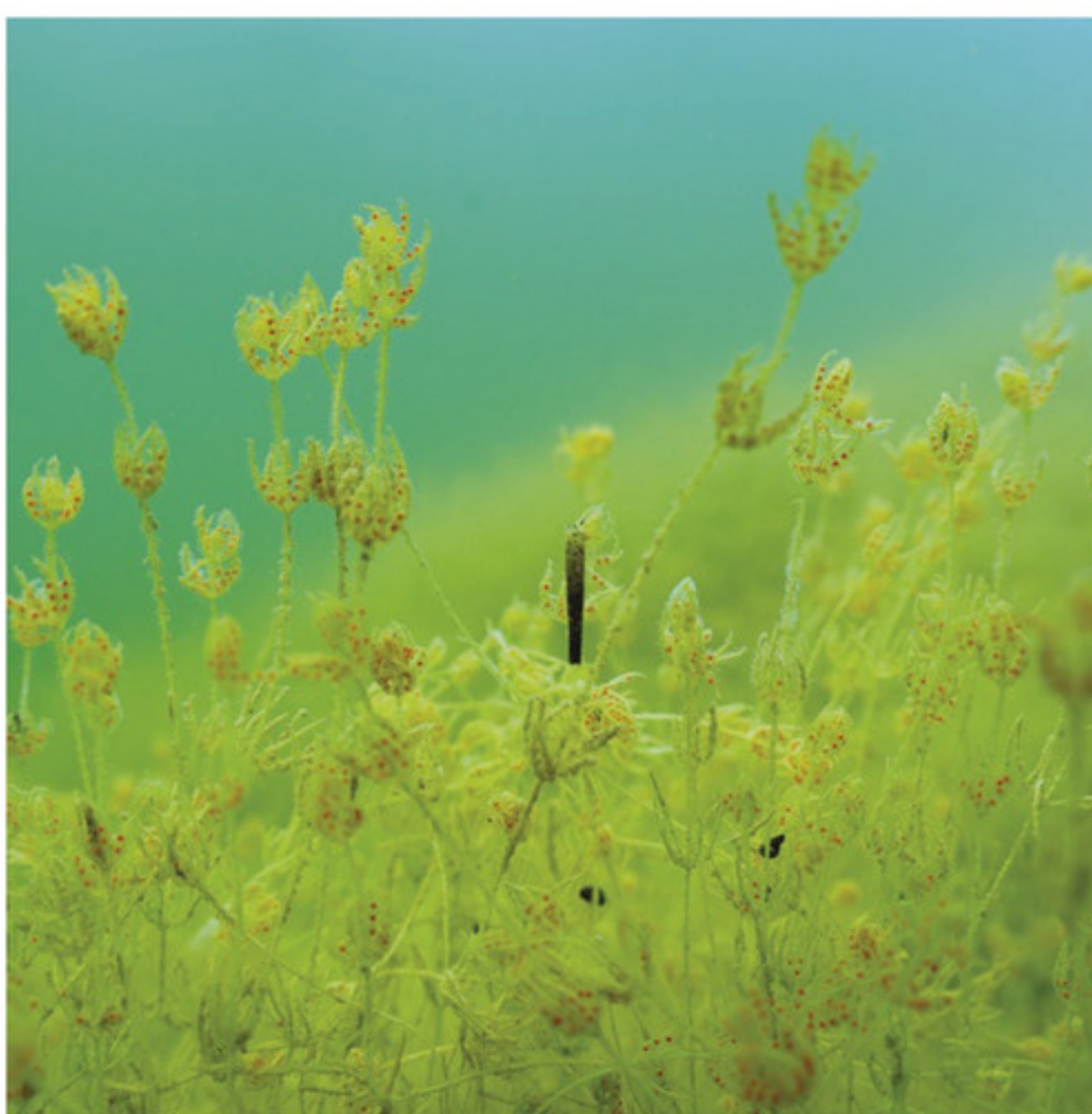
1 Pleurococci make a green layer on trees



2 microscope photo of algae

Multicellular algae include bladderwrack and stonewort. **Stonewort** (see figure 29) can be found in ponds and ditches. **Bladderwrack** (see figure 30) grows in the sea. You may come across lots of bladderwrack on the beach. The vesicles pop if you tread on them. Bladderwrack will often have turned black as it dries out.

▼ Fig. 29 Stonewort.



1 photo

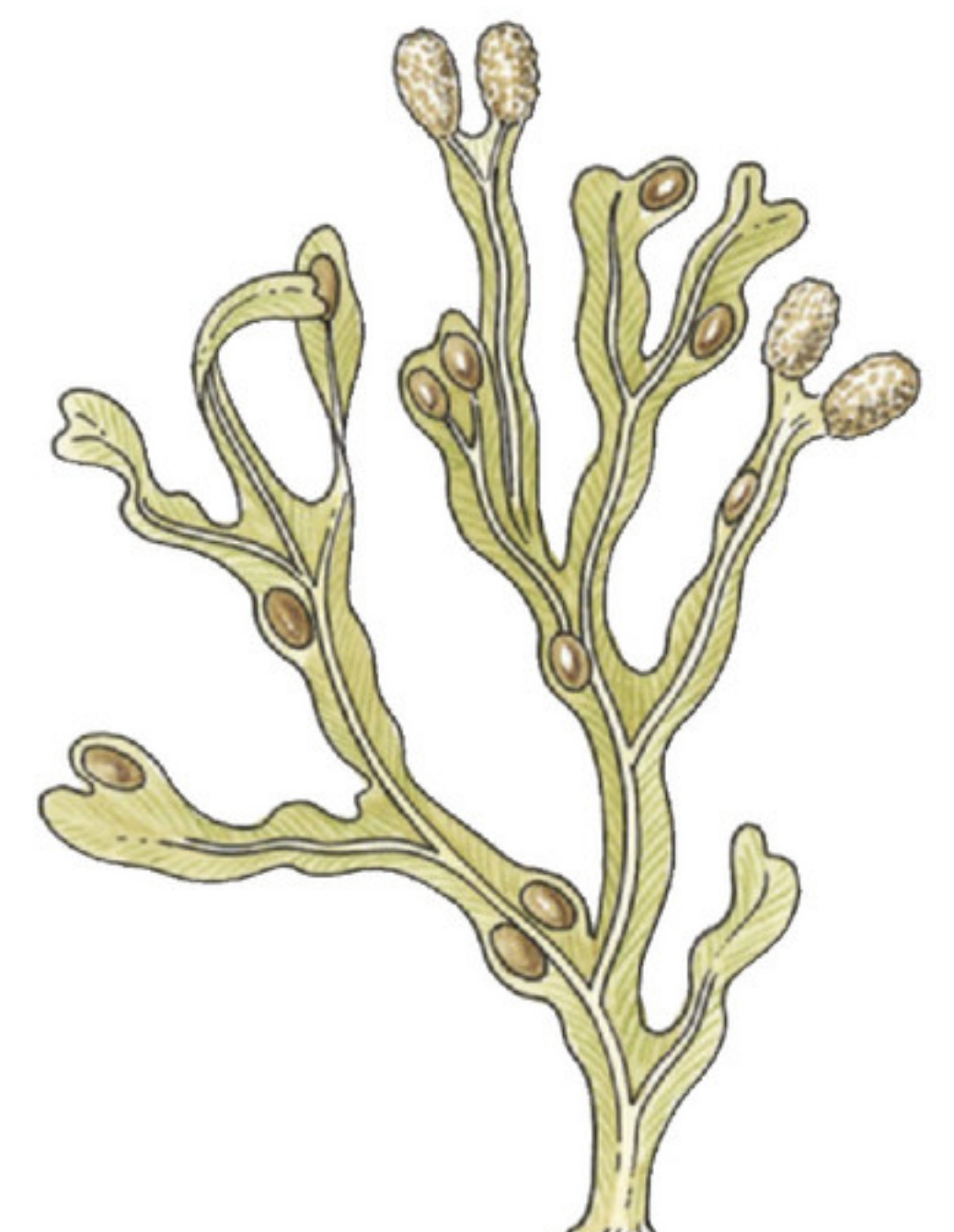


2 drawing

▼ Fig. 30 Bladderwrack.



1 photo



2 drawing

SPORE-BEARING PLANTS

Spore-bearing plants have **roots**, **stems** and **leaves**, but **no flowers**. They reproduce through **spores**. We classify plants that make spores into **mosses**, **horsetails** and **ferns**.

Mosses are small plants that are found together in groups (see figure 31.1). Their leaves are small. The spores are produced in **spore capsules** that protrude above the moss plants (see figure 31.2).

Horsetails (see figure 32.1) are made up of a kind of ‘tube’ that you can pull off one by one. The spores are made in **spore-producing organs** on the ends of some stems (see figure 32.2).

▼ **Fig. 31** Common hair moss.



1 moss plants grow in groups together



2 spore capsules on stalks

▼ **Fig. 32** Field horsetail.



1 plant



2 spore-producing organs on the ends of the stems

You can recognise **ferns** from the large leaves that usually have deep cuts in them (see figure 33.1). The spores are produced in **sporangia** (singular: sporangium) on the undersides of the leaves (see figure 33.2).

▼ **Fig. 33** Male fern.



1 plant



2 sporangia on the underside of a fern leaf

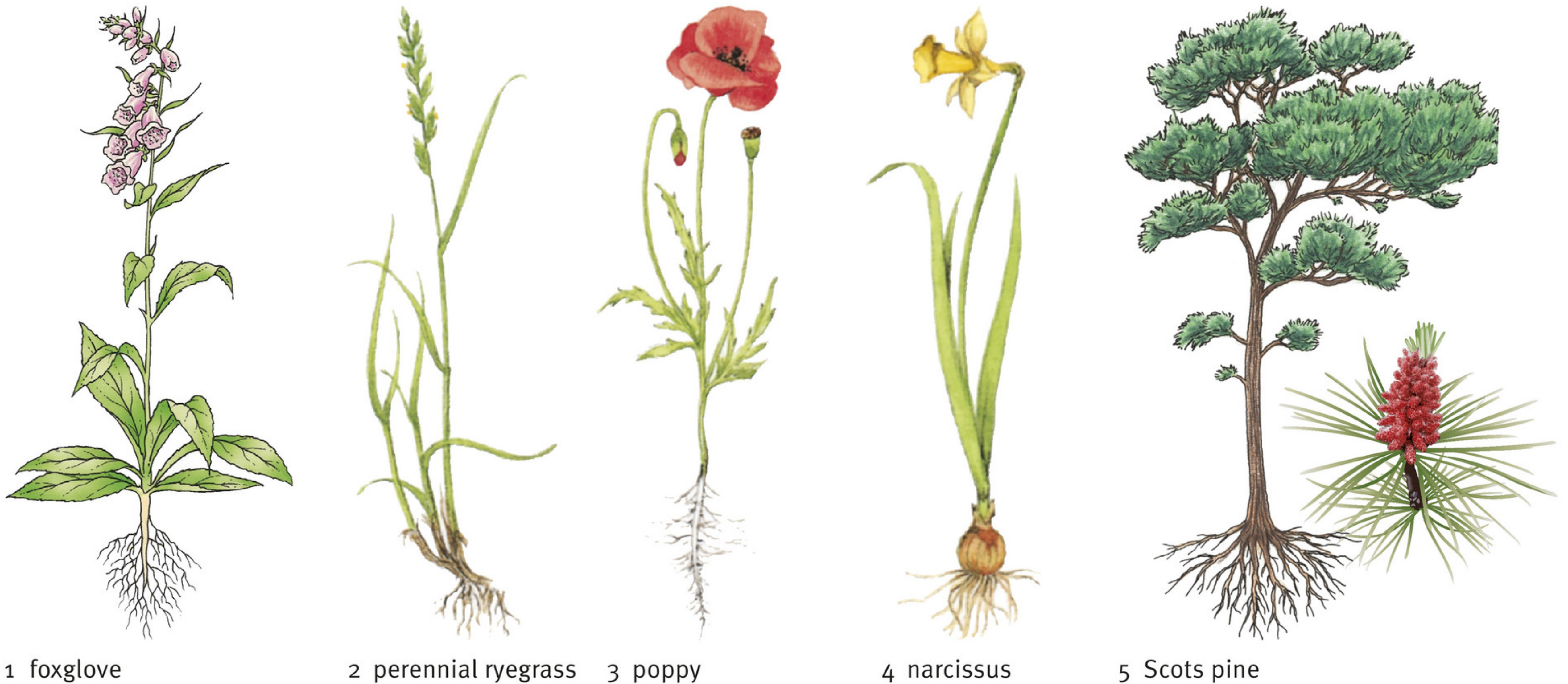
SEED-BEARING PLANTS

Seed-bearing plants have **roots, stems, leaves and flowers** (see figure 34). They reproduce through **seeds**. Seeds are produced in the flowers. Most of the plants you know are seed-bearing plants.

Seed-bearing plants include not only daisies and buttercups, but also shrubs and trees. Figures 34 to 36 show some examples of seed-bearing plants.

WB EXERCISES 15 TO 19, PAGE 109

▼ **Fig. 34** Seed-bearing plants have roots, stems, leaves and flowers.



▼ **Fig. 35** Flowering cacti.



▼ **Fig. 36** Banana plant flower.



flower unripe banana

5 The animal kingdom

Two features play key roles in subdividing the animal kingdom. These are **symmetry** and the **skeleton**.

SYMMETRY

The shape of some objects allows them to be split into two halves that are mirror images of each other (see figure 37). The object is then said to be **symmetrical**. A symmetrical object can be split into identical halves.

► **Fig. 37** Symmetry.



1 this chair is a symmetrical object



2 matched up with its mirror image, half a chair makes a whole chair again

Many organisms have a symmetrical body structure. However in many organisms, the two halves of the body are not exactly identical (see figure 38). The body of a human, for instance, looks pretty symmetrical on the outside. The organs inside are not symmetrical, however. The stomach is in the left-hand half of the torso, for example, and the liver on the right. Even so, biologists say that a human is symmetrical.

► **Fig. 38** Symmetrical?



1 photo of a face



2 the left half of the face plus its reflection



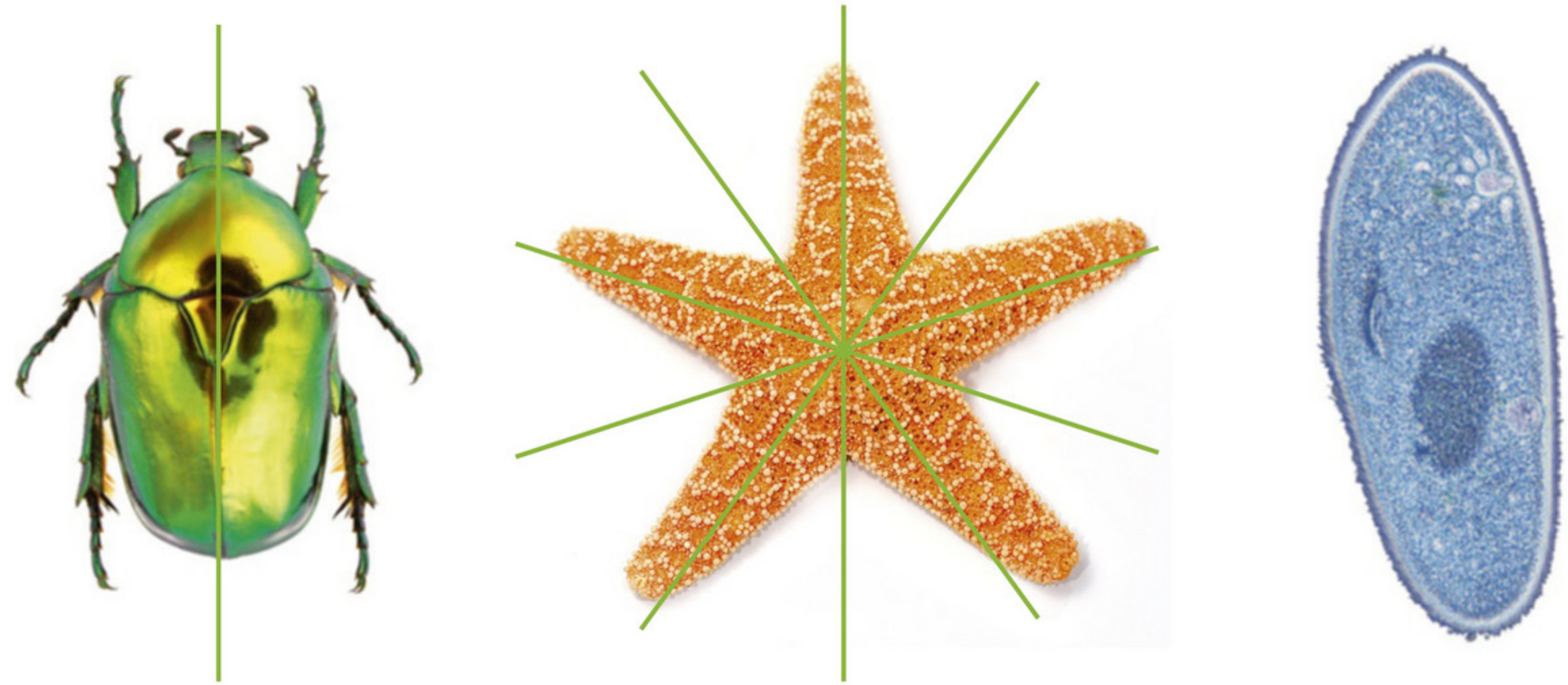
3 the right half of the face plus its reflection

Many species of animals are **bilaterally symmetrical**. There is only one way that such animals could be 'cut' to create two (roughly) equal halves. A beetle is an example of this (see figure 39.1).

Other species of animals are **radially symmetrical**. There are several ways that such animals could be 'cut' to create two (roughly) equal halves (see figure 39.2).

Animals that could not be cut in any way to make two roughly equal halves are said to be **asymmetrical**. A paramecium is an example of this (see figure 39.3). Paramecia are single-celled animals that live in water.

▼ **Fig. 39** Symmetry in animals.



1 beetle: bilaterally symmetrical

2 starfish: radially symmetrical

3 paramecium: asymmetrical

SKELETON

Many animals have rigid structures in their bodies. These stiff parts give the animals their firm shape and protect them. We call these rigid parts of the animal its **skeleton**.

▼ **Fig. 40** Animal skeletons.



1 internal skeleton of a sponge: a skeleton of tough fibres of keratin between the cells (keratin also occurs in your nails)



2 external skeleton of a mussel: its shell



3 external skeleton of a snail: its shell



4 internal skeleton of a cuttlefish: an internal shell (cuttlebone)



5 external skeleton of a ladybird: a cuticle



6 internal skeleton of a human: a skeleton of bones

In figure 40, you can see that there are various kinds of skeleton. A mussel, a snail and a ladybird have the skeleton on the outside of the body. We call that an **external skeleton**. A sponge, a cuttlefish and a human have the skeleton on the inside of the body. We call that an **internal skeleton**.

There are also animals that have **no skeleton**. Most animals without skeletons live in water.

WB EXERCISE 20, PAGE 113

▼ **Fig. 41** Animals without skeletons.



1 sea anemone



2 sea slug



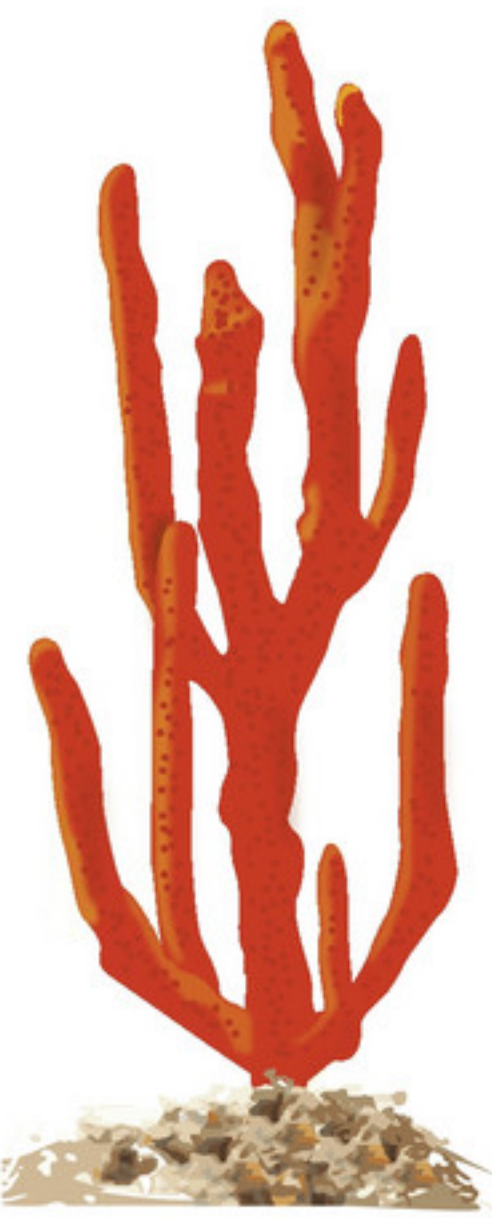
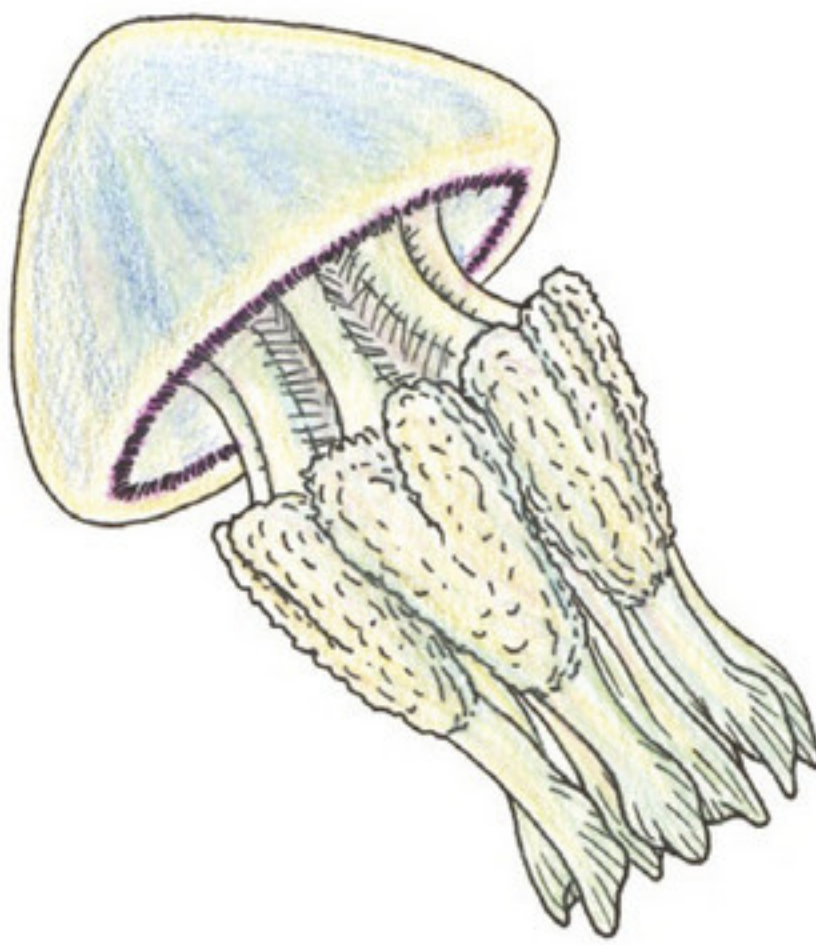
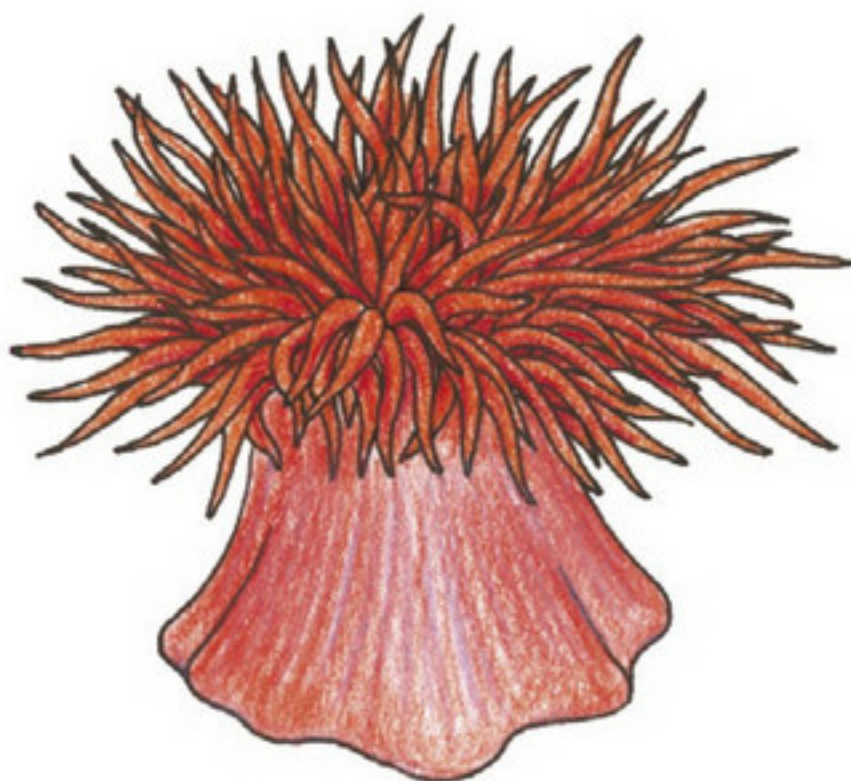
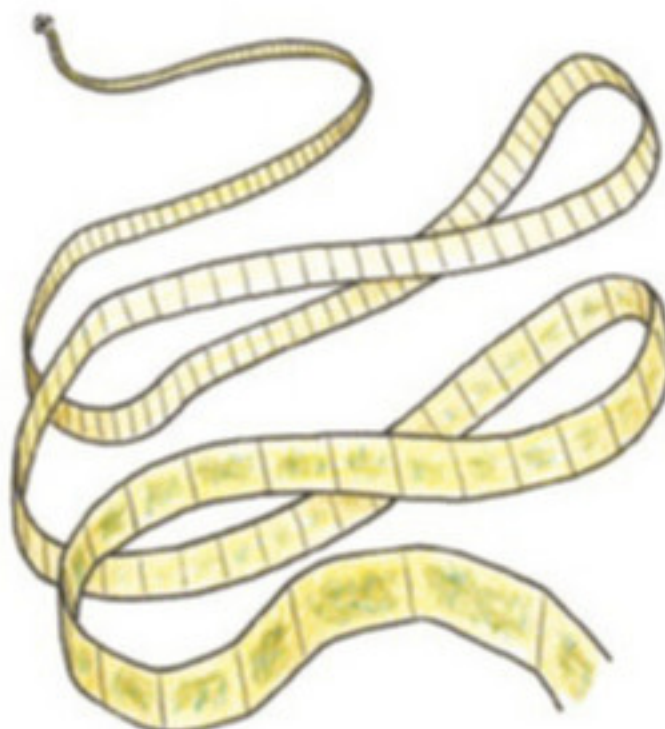
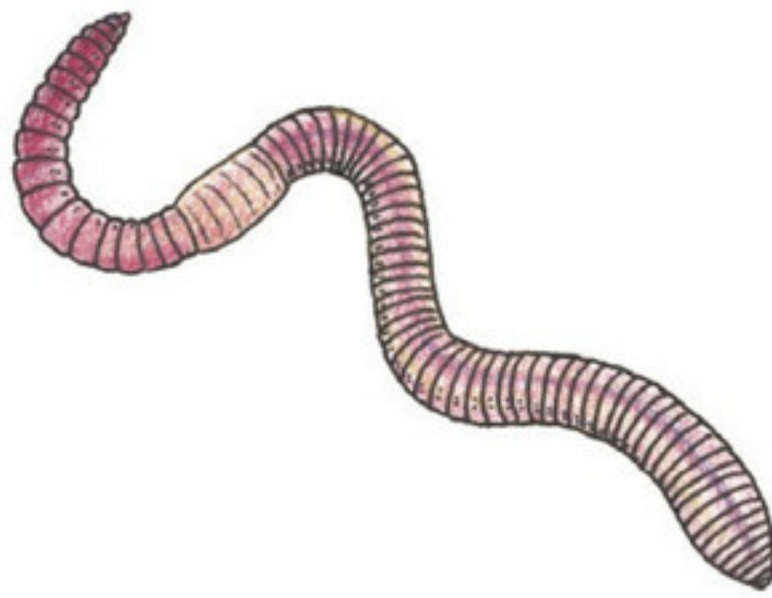
3 jellyfish

CLASSIFICATION OF THE ANIMAL KINGDOM

The animal kingdom is subdivided into about 25 phyla that include **sponges**, **cnidarians**, **molluscs**, **arthropods**, **echinoderms** and **vertebrates**. **Worms** are split into multiple phyla. Figure 42 shows these phyla with some of their features. For each phylum, a number of animals have been drawn as examples. You can see that two phyla – the arthropods and the vertebrates – have been subdivided further. These will be discussed in Basics 9 and 10. Figure 44 shows you photographs of nine animals. Exercise 23 is about these animals.

WB EXERCISES 21 TO 24, PAGE 114

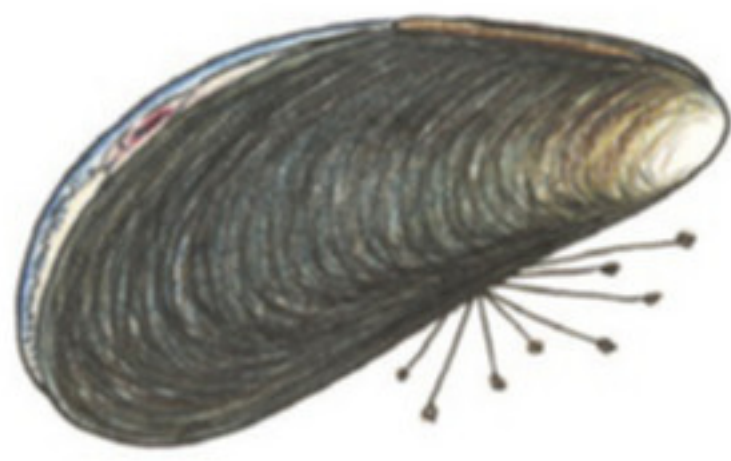
▼ Fig. 42 Some of the phyla of the animal kingdom.

1 sponges	2 cnidarians	3 worms
Features: – asymmetrical – a skeleton of tough keratin fibres between the cells – generally fixed to the seabed	Features: – radially symmetrical – generally have no skeleton – live in water – catch their prey with tentacles	Features: – bilaterally symmetrical – no skeleton – the body is long and thin
 red finger sponge  yellow tube sponge  purple tube sponge	 jellyfish  sea anemone	 tapeworm  roundworm  earthworm

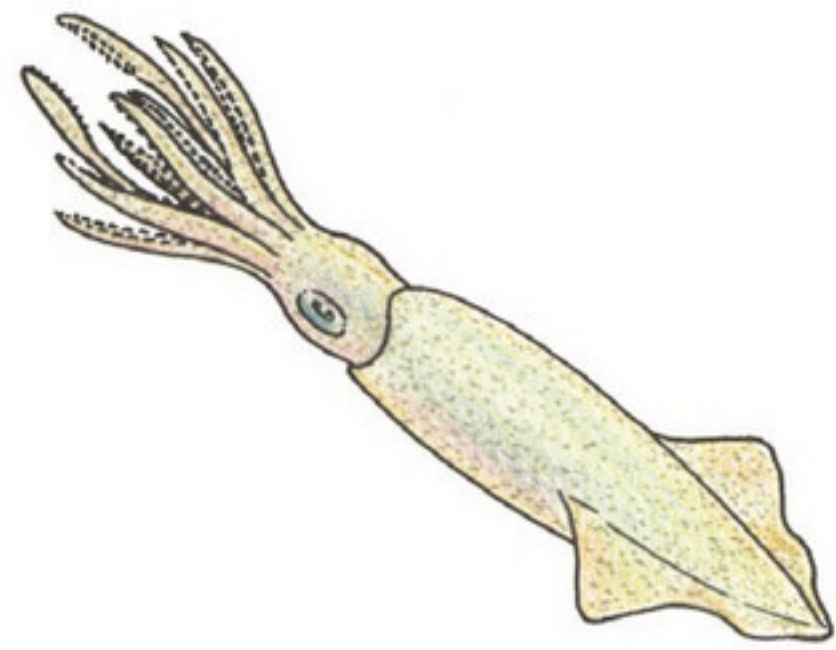
4 molluscs

Features:

- bilaterally symmetrical
- generally have a shell as the skeleton



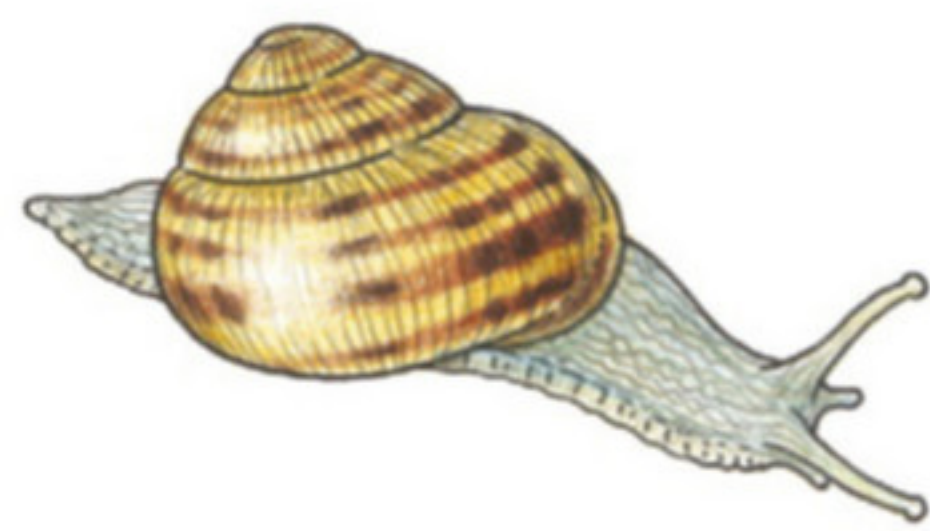
mussel



squid



sea slug



snail

5 arthropods

Features:

- bilaterally symmetrical
- the skeleton is a protective cuticle

ARACHNIDS

spider

INSECTS

fly

CRUSTACEANS

crab

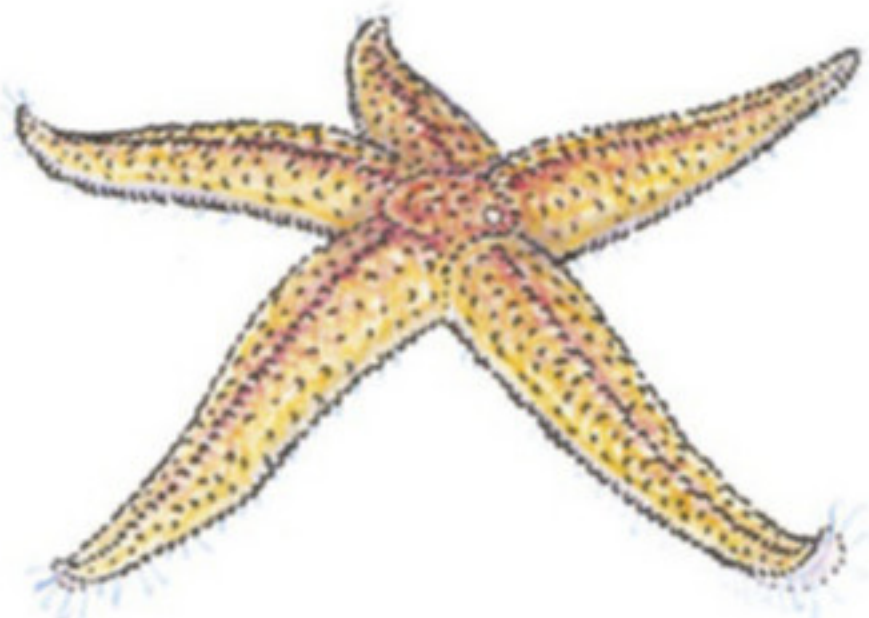
MYRIAPODS

centipede

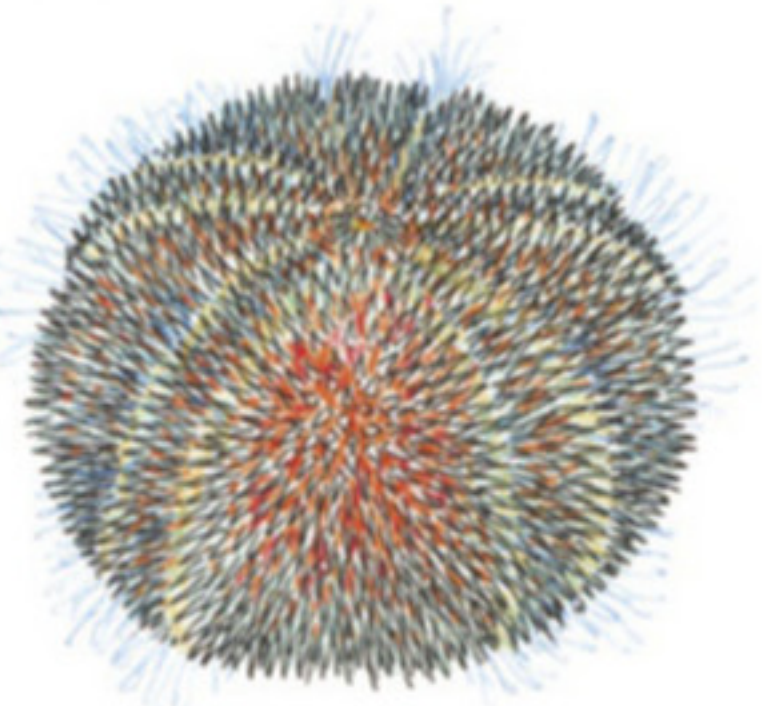
6 echinoderms

Features:

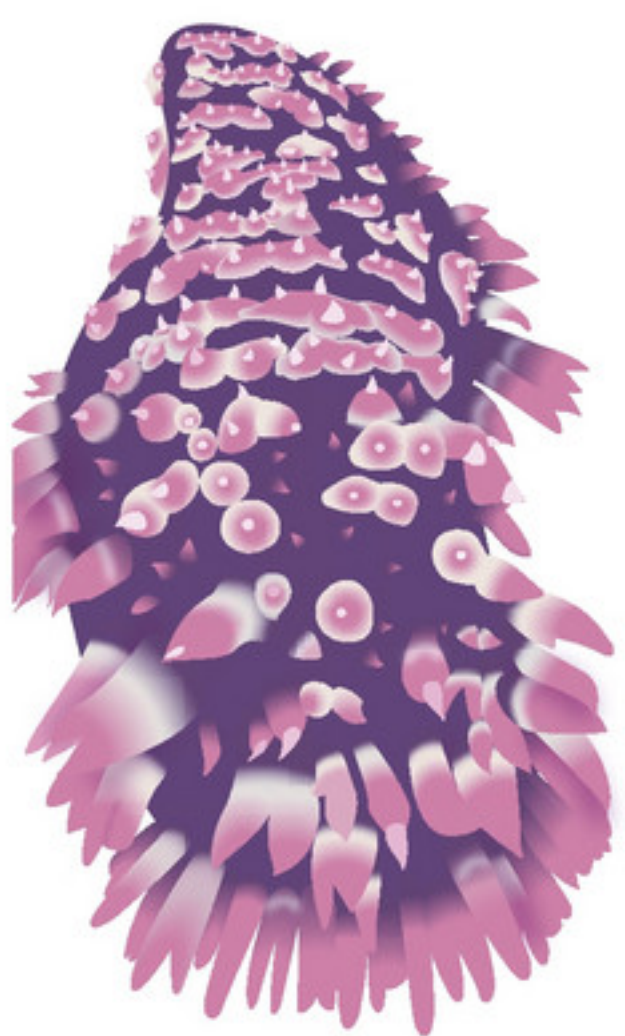
- radially symmetrical
- internal skeleton of calcium carbonate
- the skin is covered with spines or nodules
- live on the seabed



starfish



sea urchin

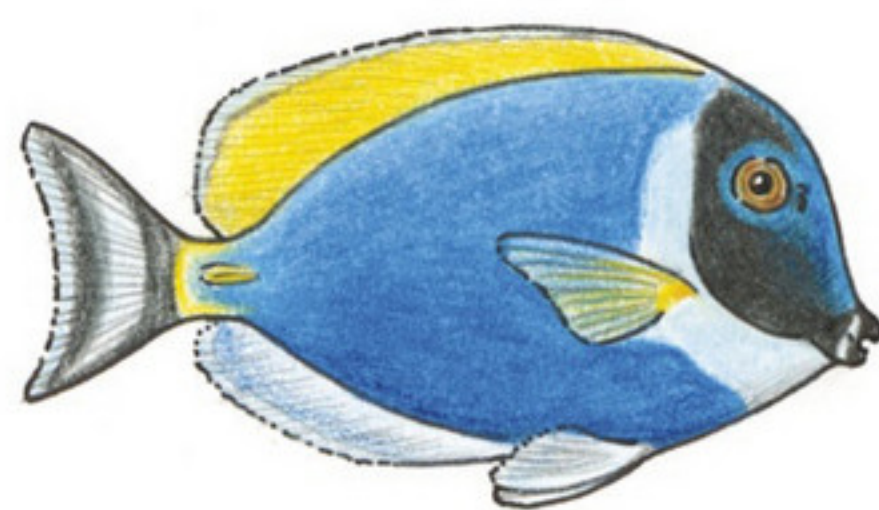


sea cucumber

7 vertebrates

Features:

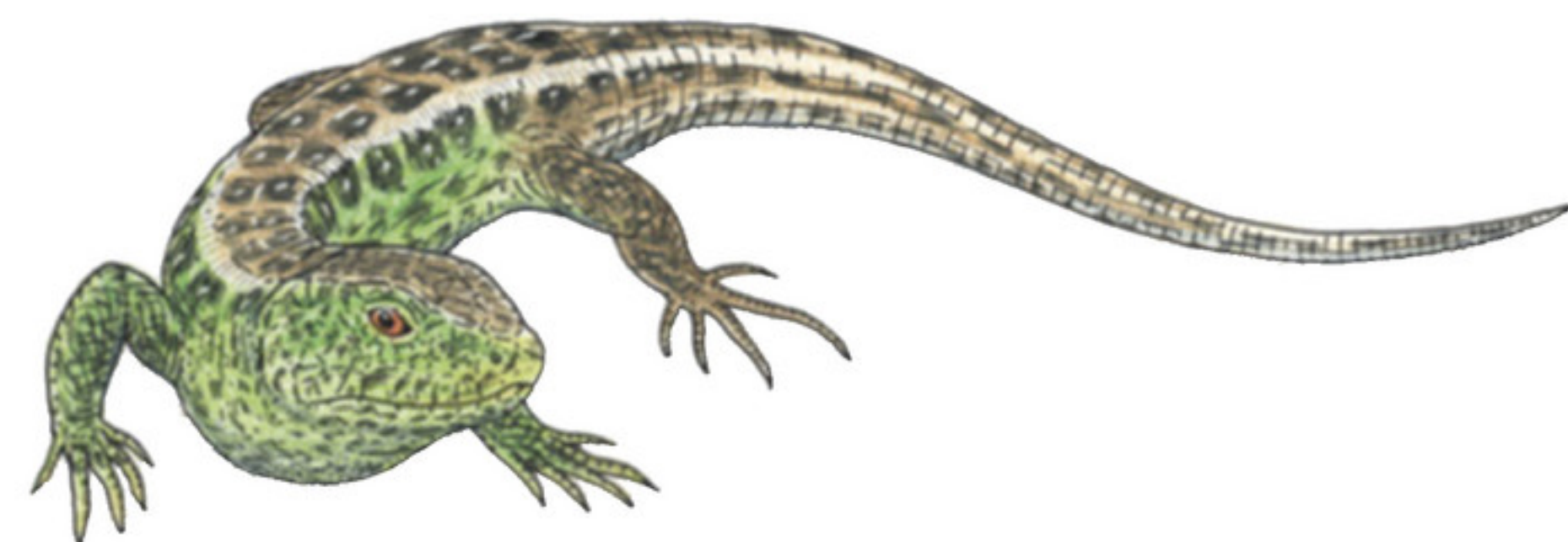
- bilaterally symmetrical
- an internal skeleton

FISHES

surgeonfish

AMPHIBIANS

tree frog

REPTILES

sand lizard

BIRDS

red ibis

MAMMALS

badger

▼ Fig. 43 Coral reef in the Red Sea near Egypt.



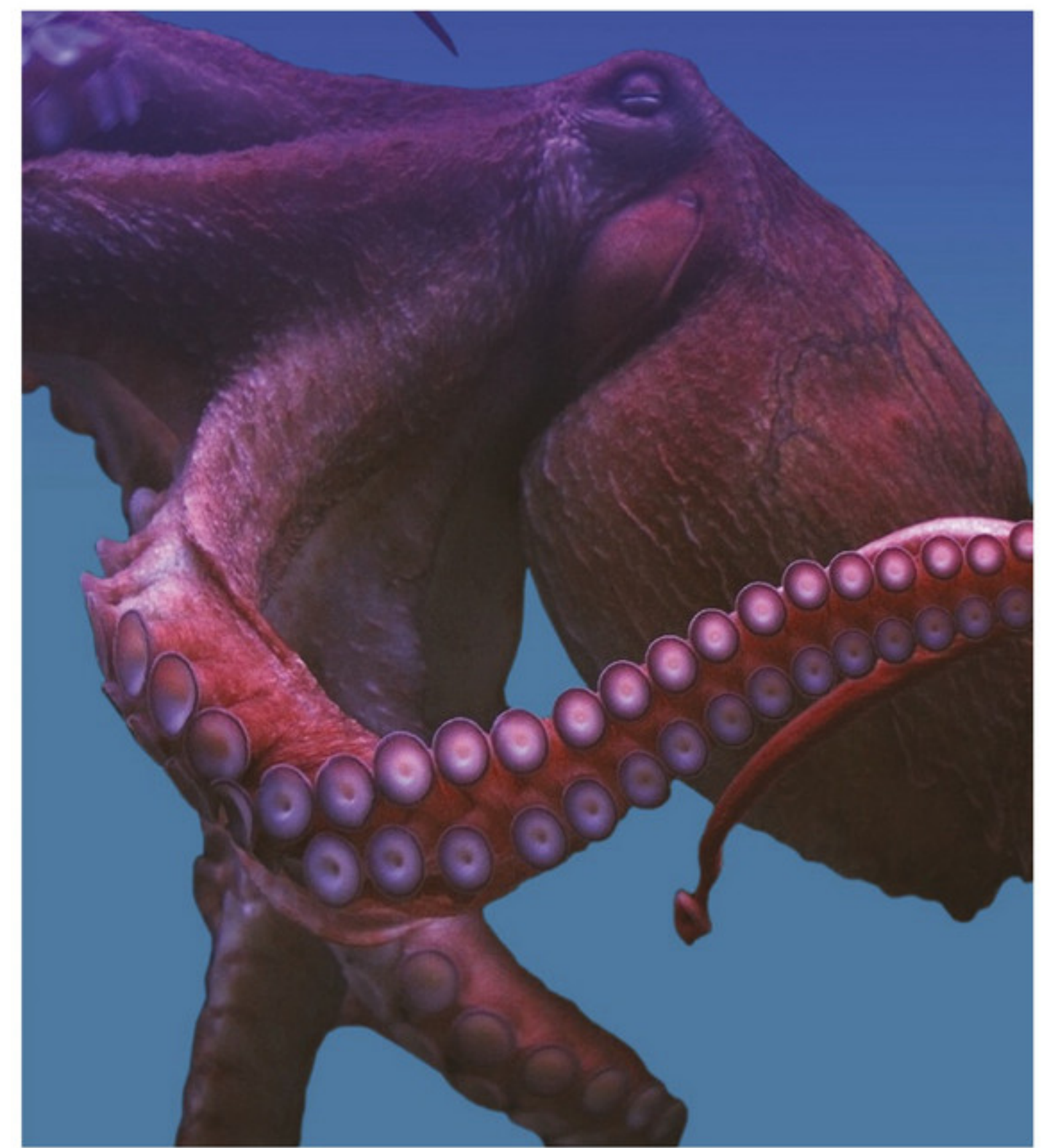
▼ Fig. 44



1



2



3



4



5



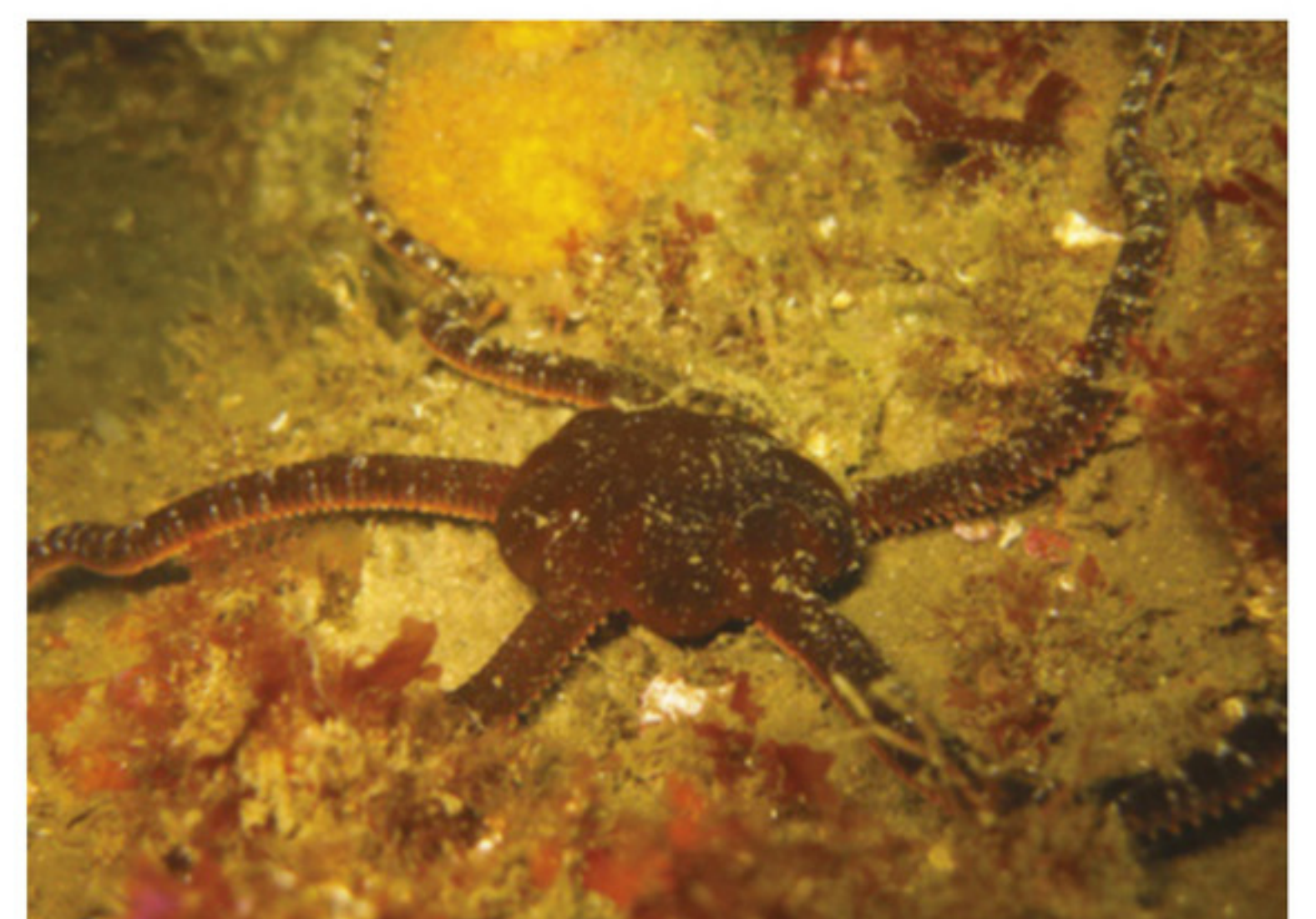
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7



8



9

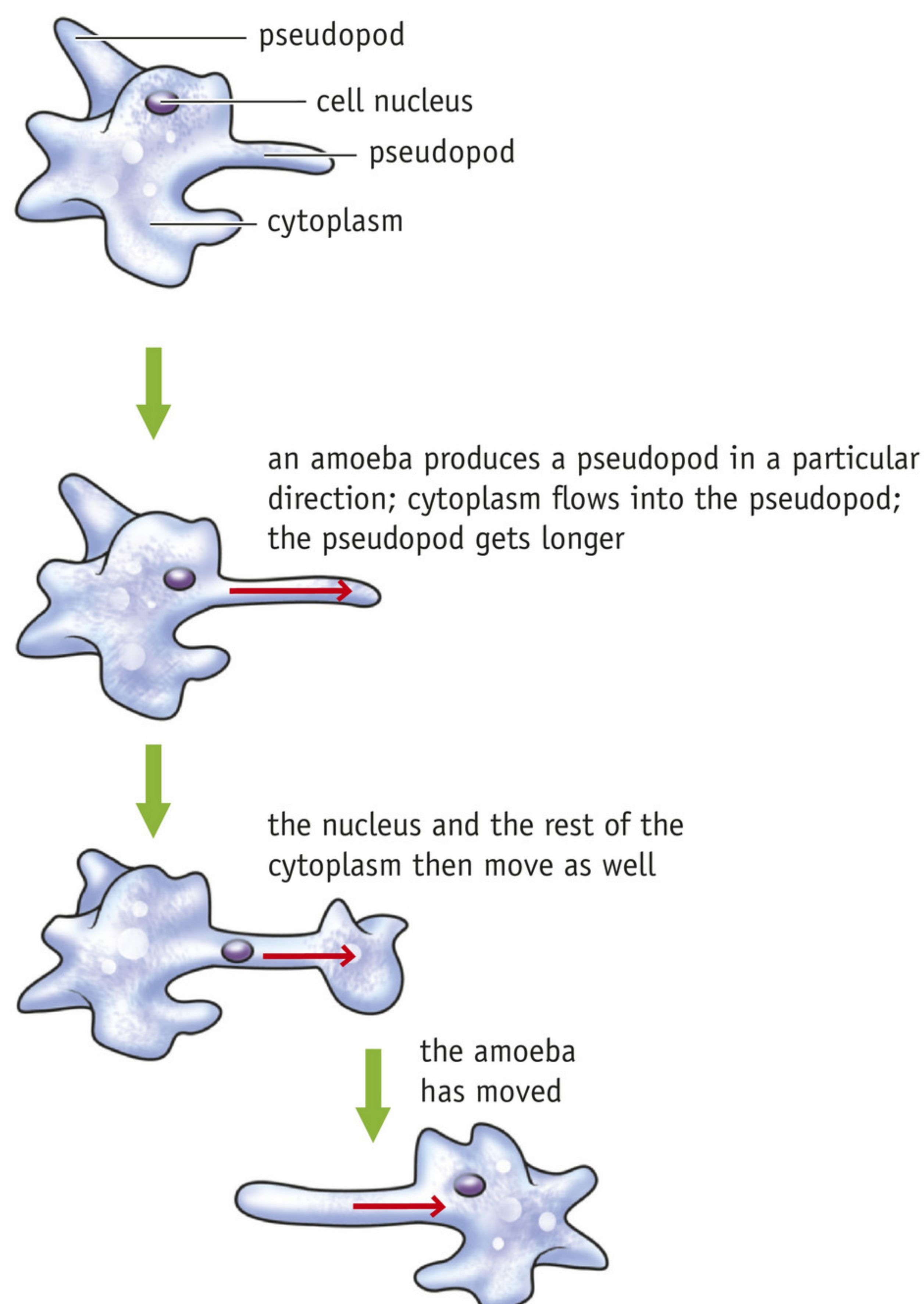
6 Other unicellular eukaryotes

You have already come across some unicellular eukaryotes such as algae and yeasts. Algae have the cellular characteristics of plants. The cells of a yeast have the features of fungi. There are also single-celled eukaryotes with the cellular characteristics of animals (no cell wall). Biologists often no longer classify these unicellular organisms with the animals, because their DNA is simply too different from animals. In all unicellular eukaryotes, a single cell shows all the life processes, such as moving and feeding. Two examples of single-celled eukaryotes with the cellular features of animals are the **amoeba** and the **paramecium**. Both these live in water, for instance in ditches and pools.

AMOEBA

An amoeba can keep changing shape. The **cytoplasm** (the fluid in the cell) can flow in particular directions and create protrusions known as **pseudopods**. Moving the cytoplasm around into pseudopods allows the amoeba to move (see figure 45).

▼ **Fig. 45** Locomotion in an amoeba.



Creating pseudopods is also how an amoeba can get to food and enclose it. The food of an amoeba includes bacteria. A bacterium becomes fully enclosed and encased inside the cell. This then creates a **food vacuole**. You must not confuse a food vacuole with the vacuoles in plant cells. The food vacuole is where the food is being digested. The digested substances are absorbed into the cytoplasm. Undigested residues are eliminated through the **cell membrane**.

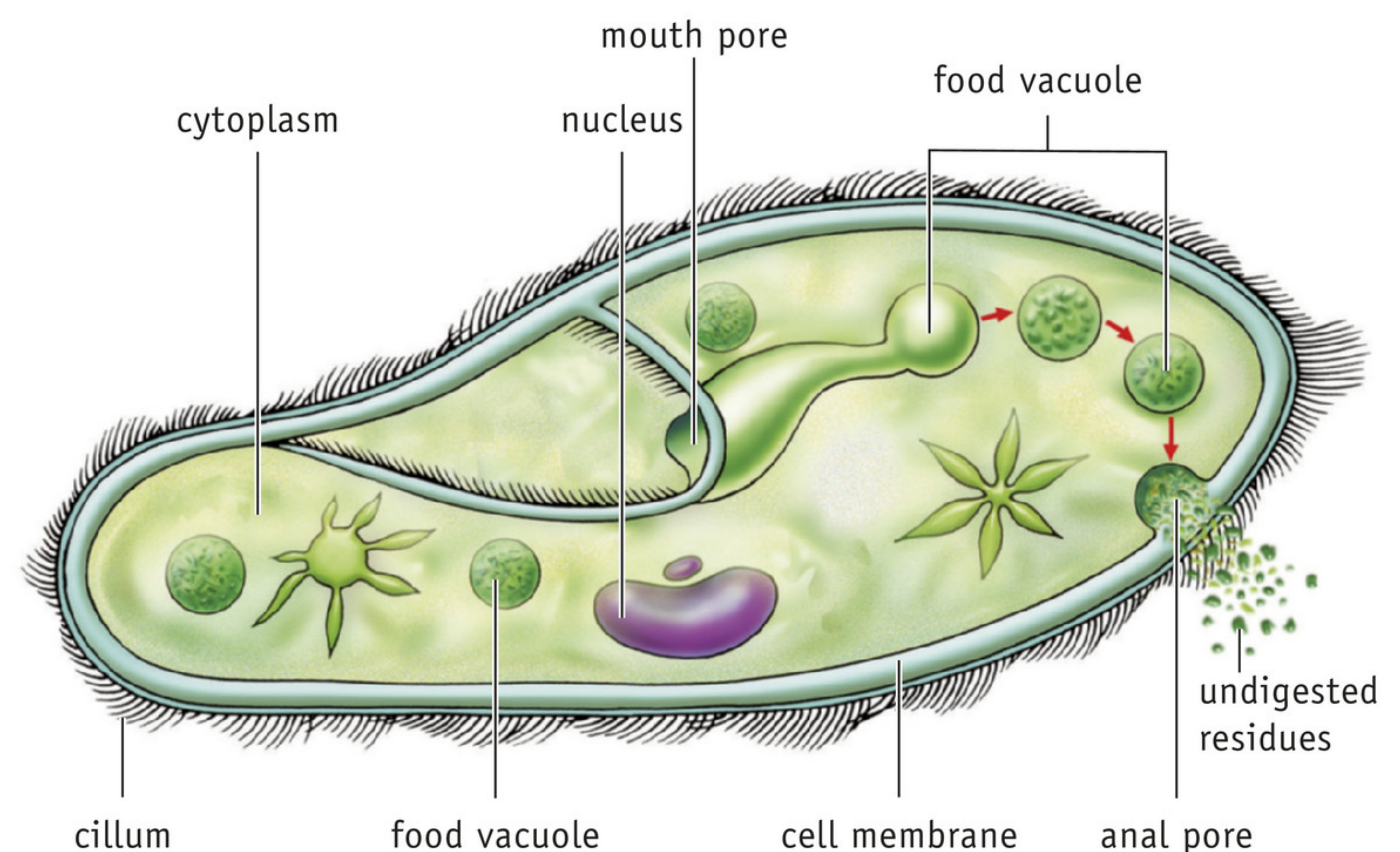
PARAMECIUM

A paramecium (see figure 46) has a more complex structure than an amoeba. There are small **cilia** (singular: cilium) on the cell membrane. These are vibrating hairs that wave around in the water, allowing the paramecium to move.

The cilia also move food into the **mouth pore**. The mouth pore is an indentation in the cell surface. Via the mouth pore the food ends up in a **food vacuole**. This is where the food is digested. The digested substances are absorbed into the cytoplasm. Undigested residues are eliminated through the **anal pore**.

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▼ **Fig. 46** Paramecium.



7 Classifying into smaller groups

You have learned that all organisms can be classified into smaller and smaller groups: the **domains**, the **kingdoms** and the **phyla**. Phyla still sometimes contain huge numbers of species. The phyla are therefore classified further into smaller and smaller groups (see figure 47).

▼ **Fig. 47** Classifying organisms into smaller and smaller groups.

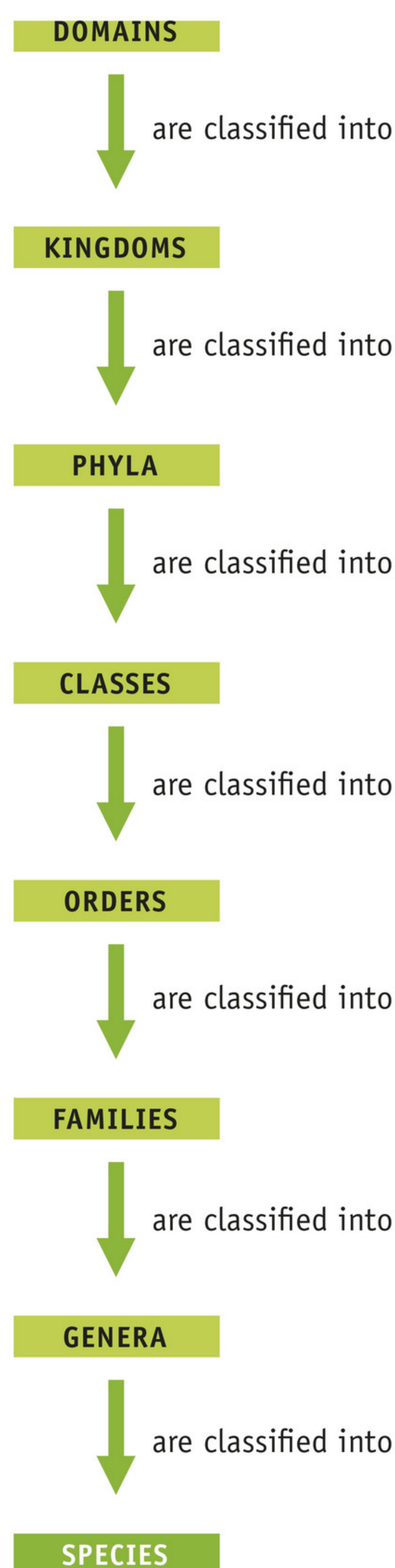
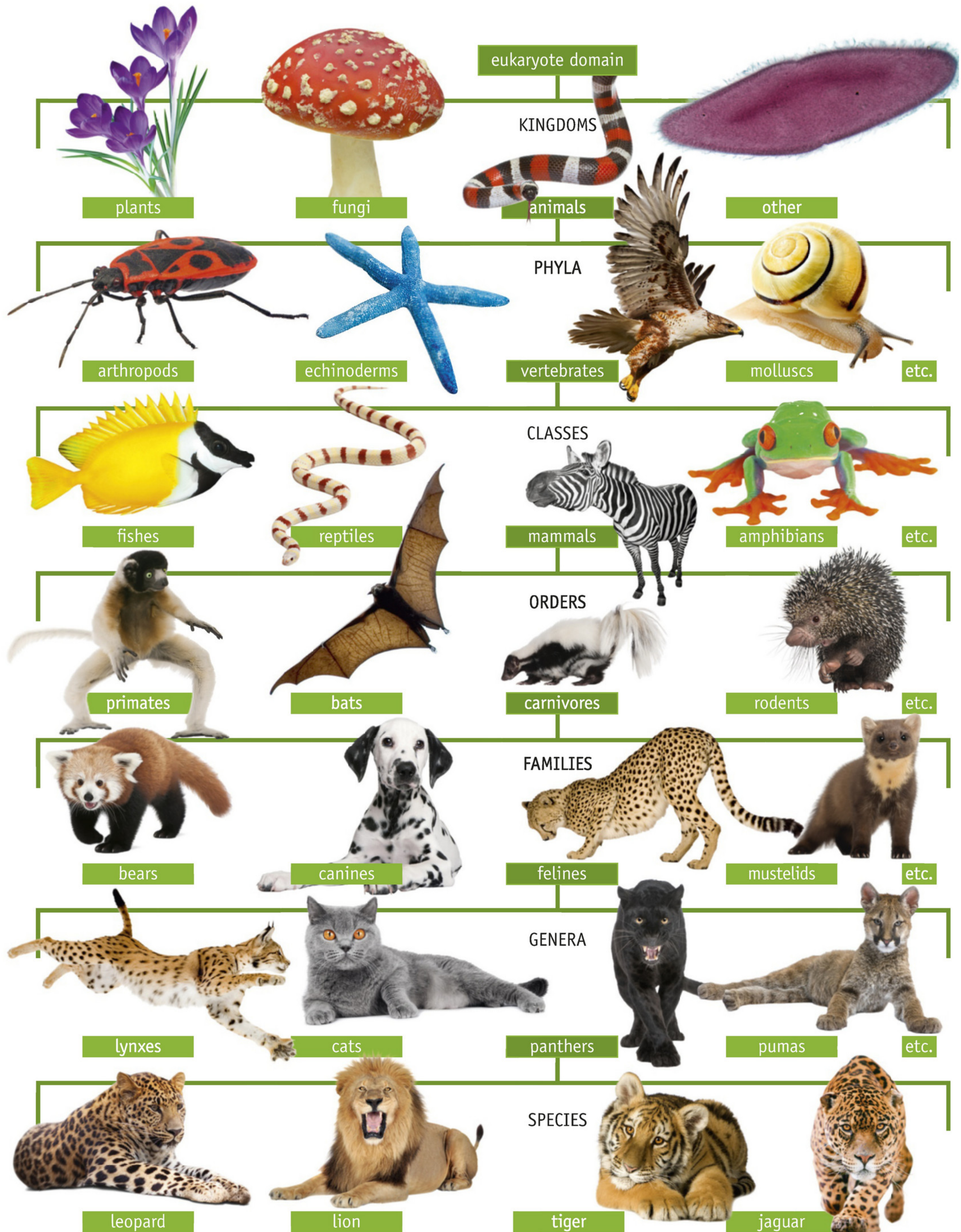


Figure 48 shows you the subdivisions from figure 47, with examples. The eukaryote domain is subdivided into the kingdoms of plants, fungi and animals. Only the further subdivisions of the animal kingdom are shown here. You have already learned about seven phyla of the animal kingdom. In figure 48, you can see four of them as examples.

Phyla are then subdivided into **classes**. You can see that the vertebrate phylum has been divided again into four classes (just as an example), and so on. Each time, one group is taken as an example and it is then subdivided further. The classes are subdivided into **orders**. Orders are subdivided into families. Each family is made up of **genera** (the plural of genus). And a genus is subdivided into **species**. You have learned that a species can also be made up of different **breeds**. These are general breeds of animals that have been bred by humans, or plant varieties that have been cultivated by humans.

▼ Fig. 48 Further subdivisions of the eukaryote domain.



SIMILARITY

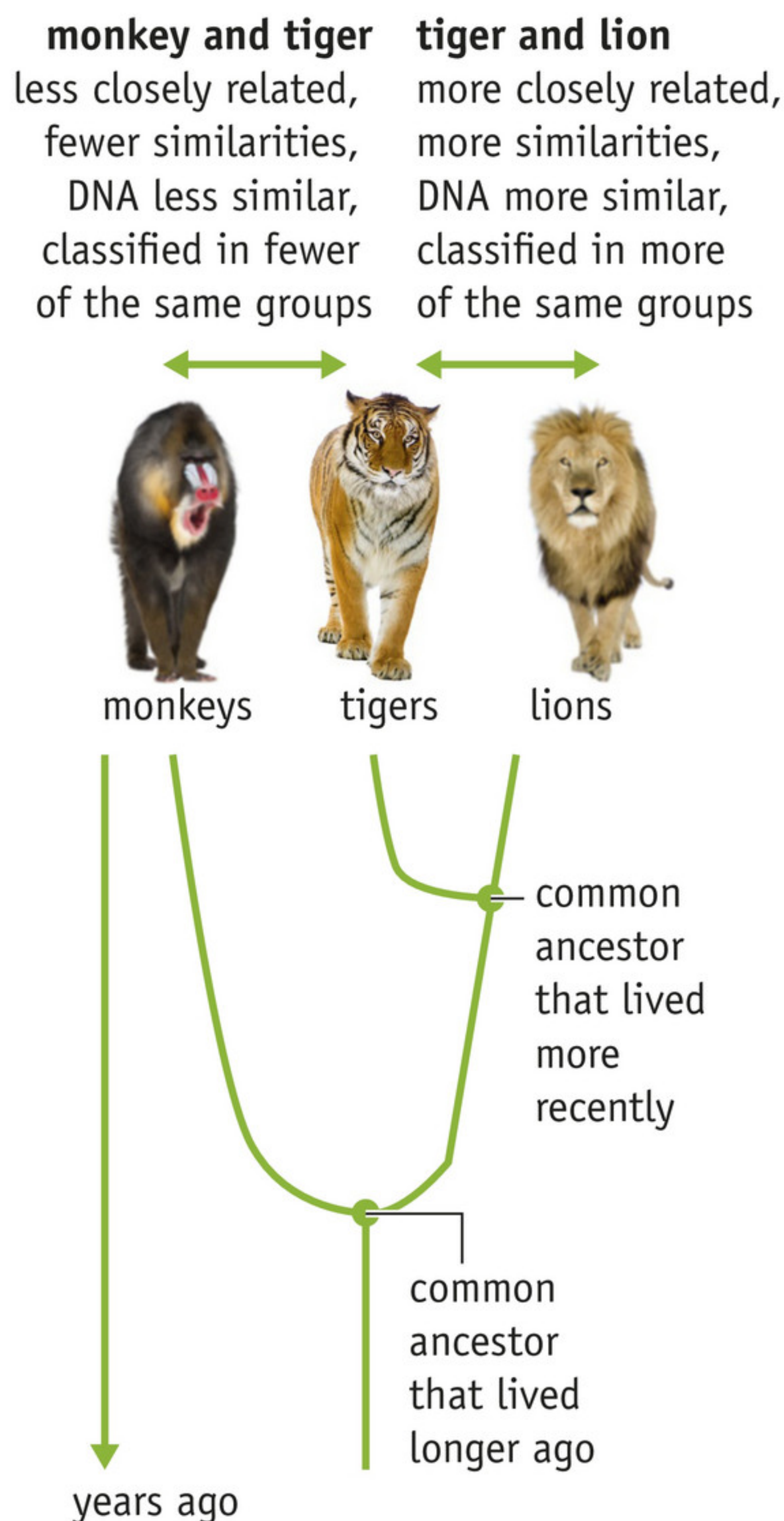
In figure 48, you can see that animals from the same genus have many more **similarities** than animals that are merely from the same domain and the same kingdom. The lion and the tiger look much more alike than the starfish and the bird of prey. The starfish and the bird of prey only belong to the same domain and kingdom. The lion and the tiger, though, also belong to the same phylum, the same class, the same order, the same family and the same genus.

The more two organisms are classified into the same groupings, the more similarities there are between these organisms. The DNA of the organisms will also show more and more similarities.

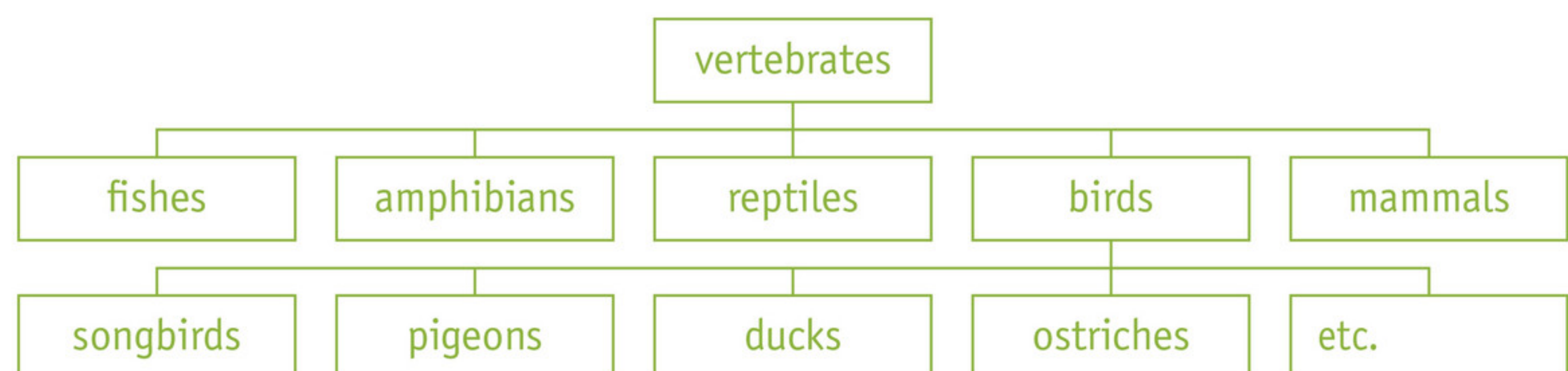
You have learned that the DNA of organisms that belong to the same species has a lot of similarities. Organisms (and their DNA) are most alike when they belong to the same species, and are least alike when they come from different domains.

The way in which we classify organisms into smaller and smaller groups can be represented in a **branching tree**. Figure 48 is actually a branching tree with photos. Figure 49 shows a branching tree in schematic form for the vertebrate phylum. A number of orders of the class 'birds' are also shown.

▼ **Fig. 50** Ancestry of apes, tigers and lions.



▼ **Fig. 49** Branching tree of the vertebrates.



CLOSELY RELATED?

In Unit 1, you learned that organisms can change slowly as a result of variation and selection. Over long periods of time, species can change a great deal. You have learned that this is called 'evolution'. Different species may arise from a common ancestor. These species and their DNA will have a lot of similarities and they will be **closely related** to each other.

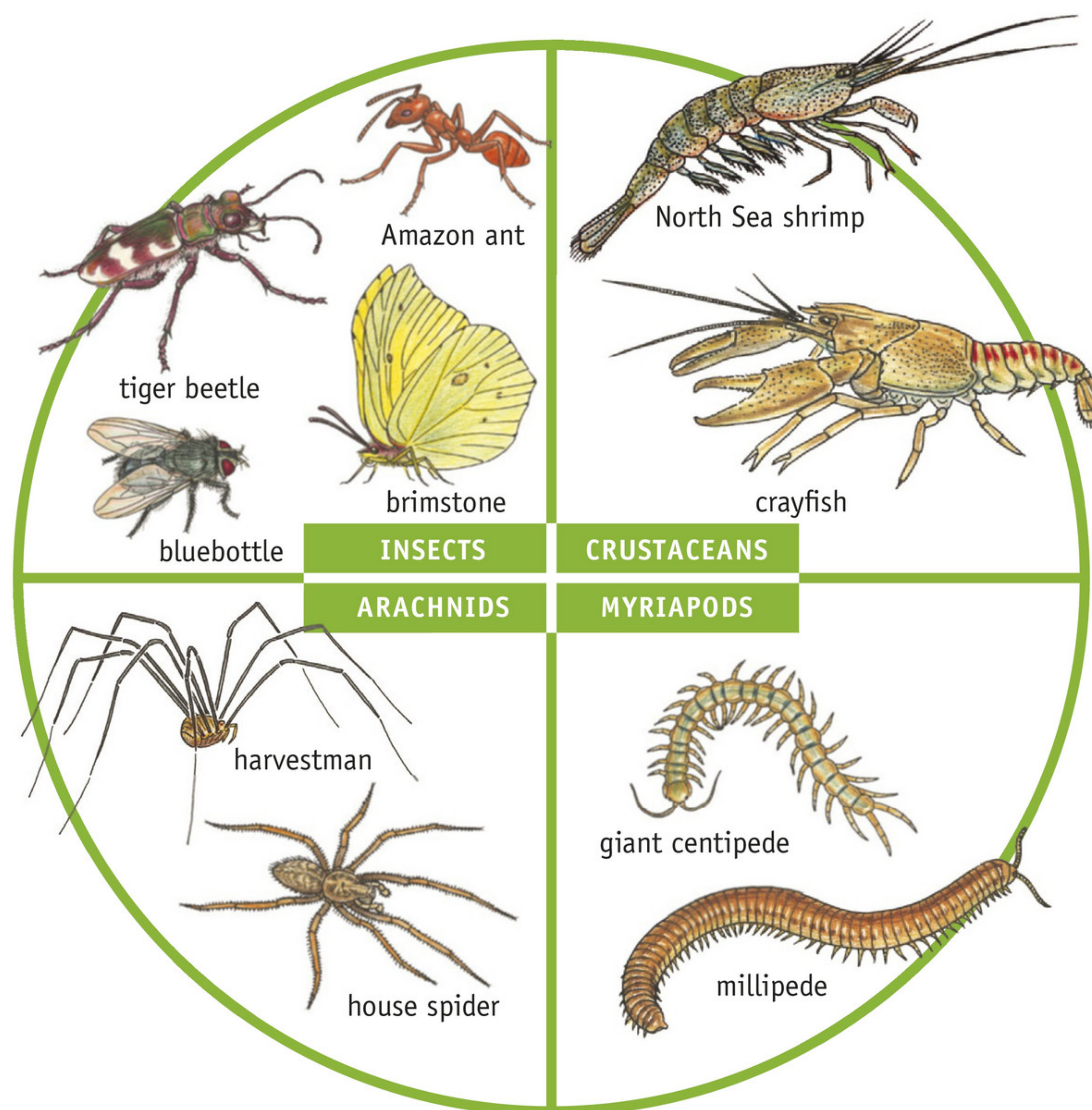
The longer ago that two species had a common ancestor, the less closely related they are. The common ancestor of a tiger and an ape lived longer ago than the common ancestor of a tiger and a lion (see figure 50). The ape and the tiger are less closely related than the lion and the tiger. The more species (and their DNA) look alike, the more closely related they are and the more they will be classified into the same groups.

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8 The arthropod phylum

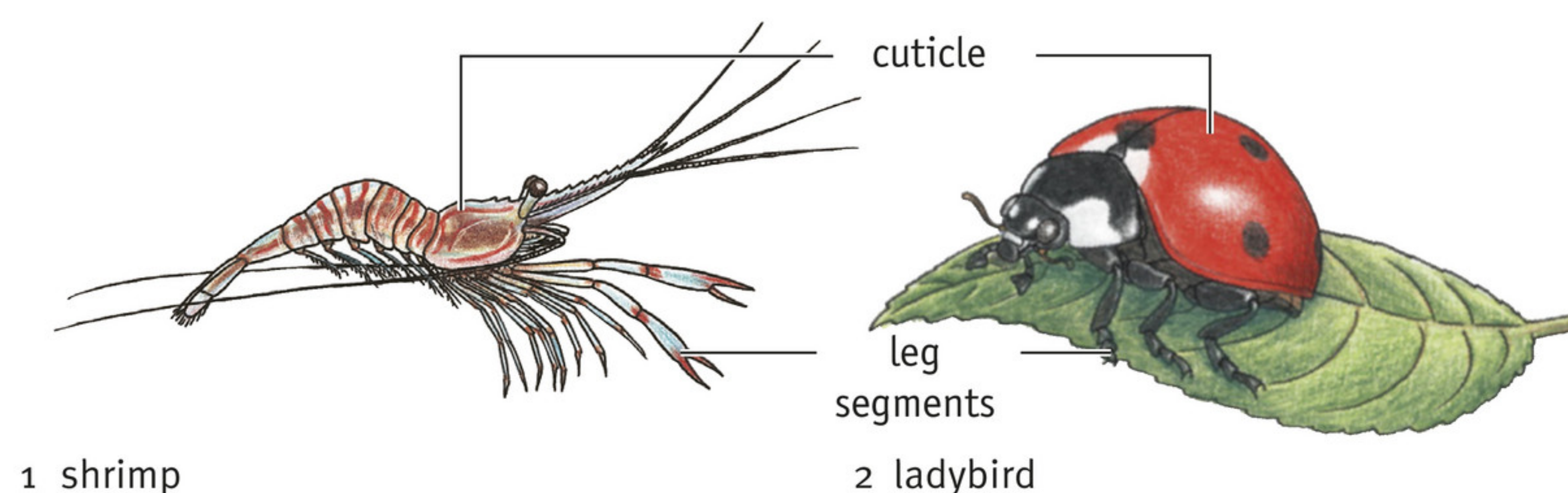
The arthropod phylum is subdivided into a large number of different classes. Most of these classes belong to one of four groups: **crustaceans**, **myriapods**, **arachnids** and **insects** (see figure 51).

▼ **Fig. 51** Classification of arthropods into four groups.

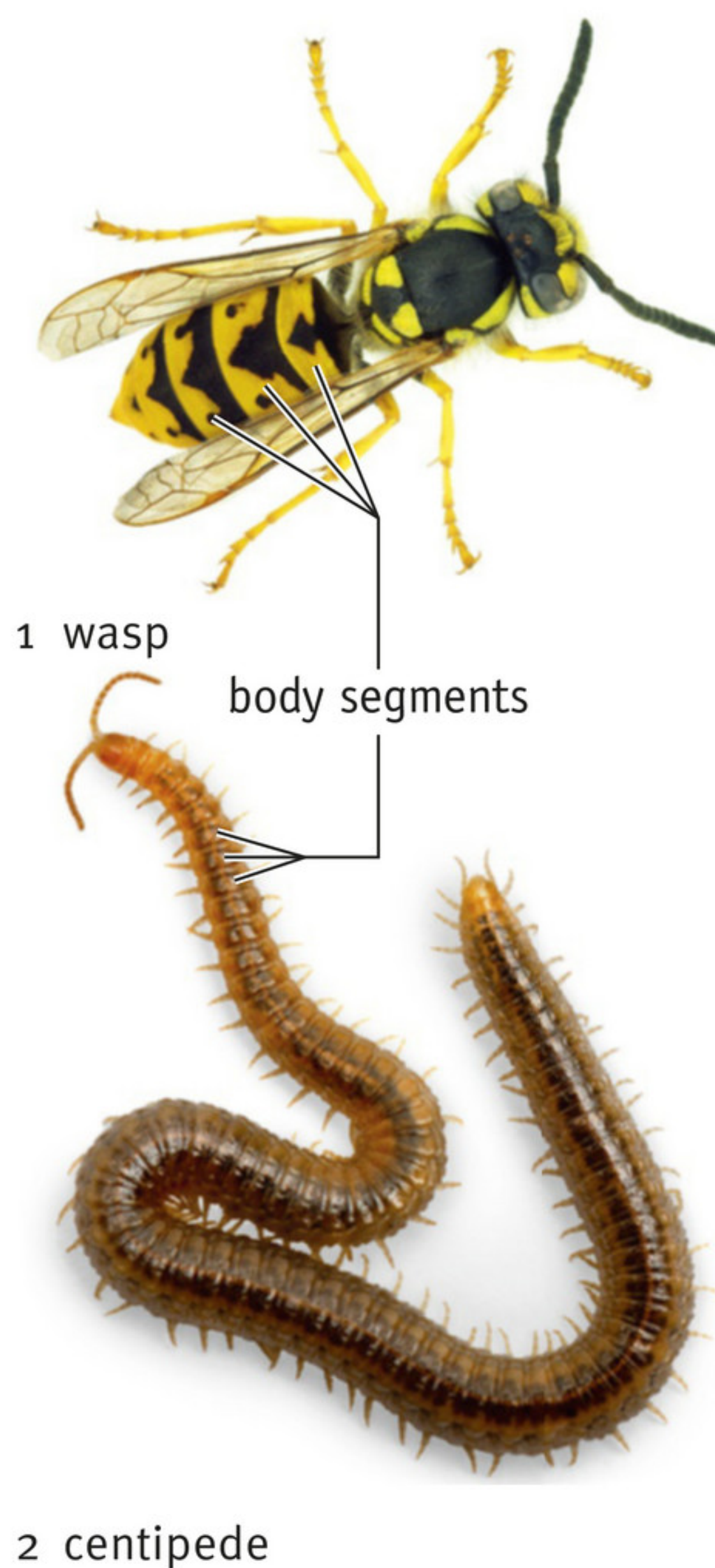


Arthropods have an external skeleton called a **cuticle** as a kind of armour around them. The legs of arthropods are jointed or **segmented** (the word arthropod means 'jointed legs'). In other words they are made up of smaller pieces, the **leg segments** (see figure 52).

▼ **Fig. 52**



▼ **Fig. 53** The body of an arthropod consists (at least partly) of segments.

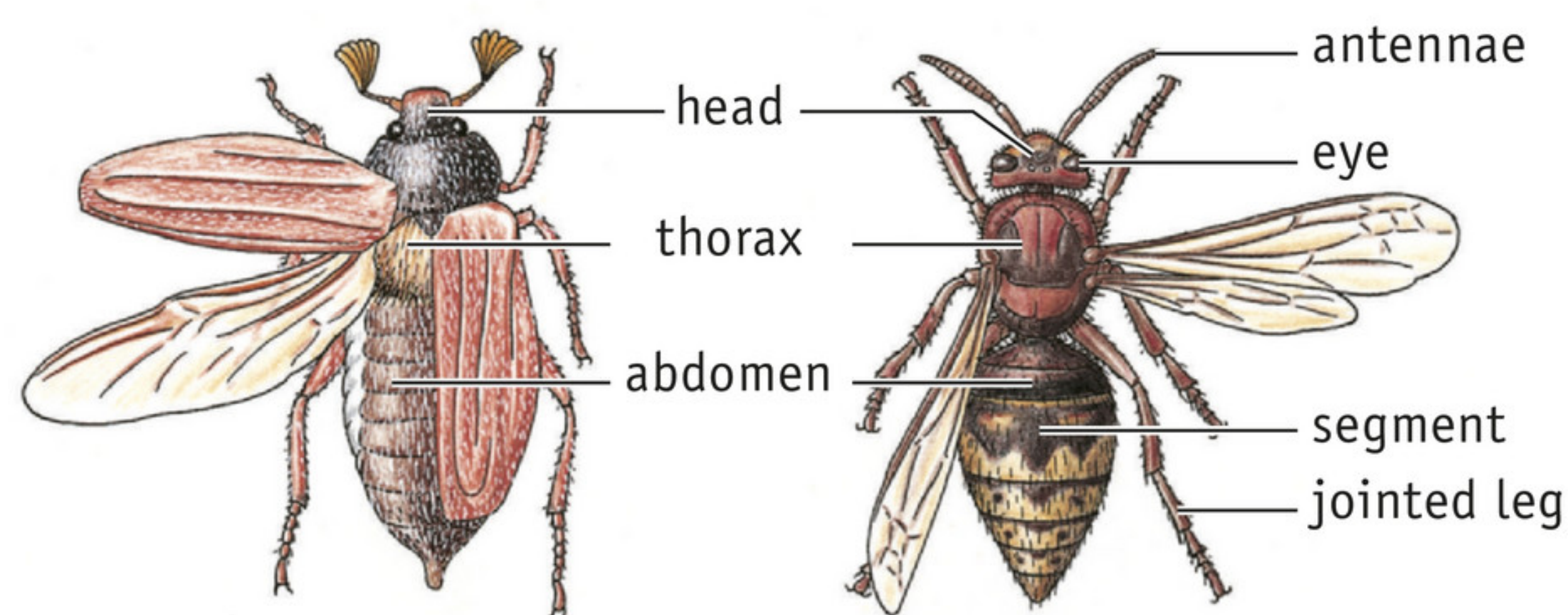


The bodies of arthropods are also **segmented**. In other words, their bodies are also made up of smaller pieces, the **body segments**. In many arthropods, such as insects, only the abdomen (the rear part) consists of segments (see figure 53.1). In **myriapods**, the entire body consists of segments (see figure 53.2). There are legs on each segment

INSECT BODY STRUCTURE

The body of an **insect** is made up of a **head**, a **thorax** and an **abdomen** (see figure 54). The head has eyes and antennae. There are legs on the thorax and, in most insect species, wings as well.

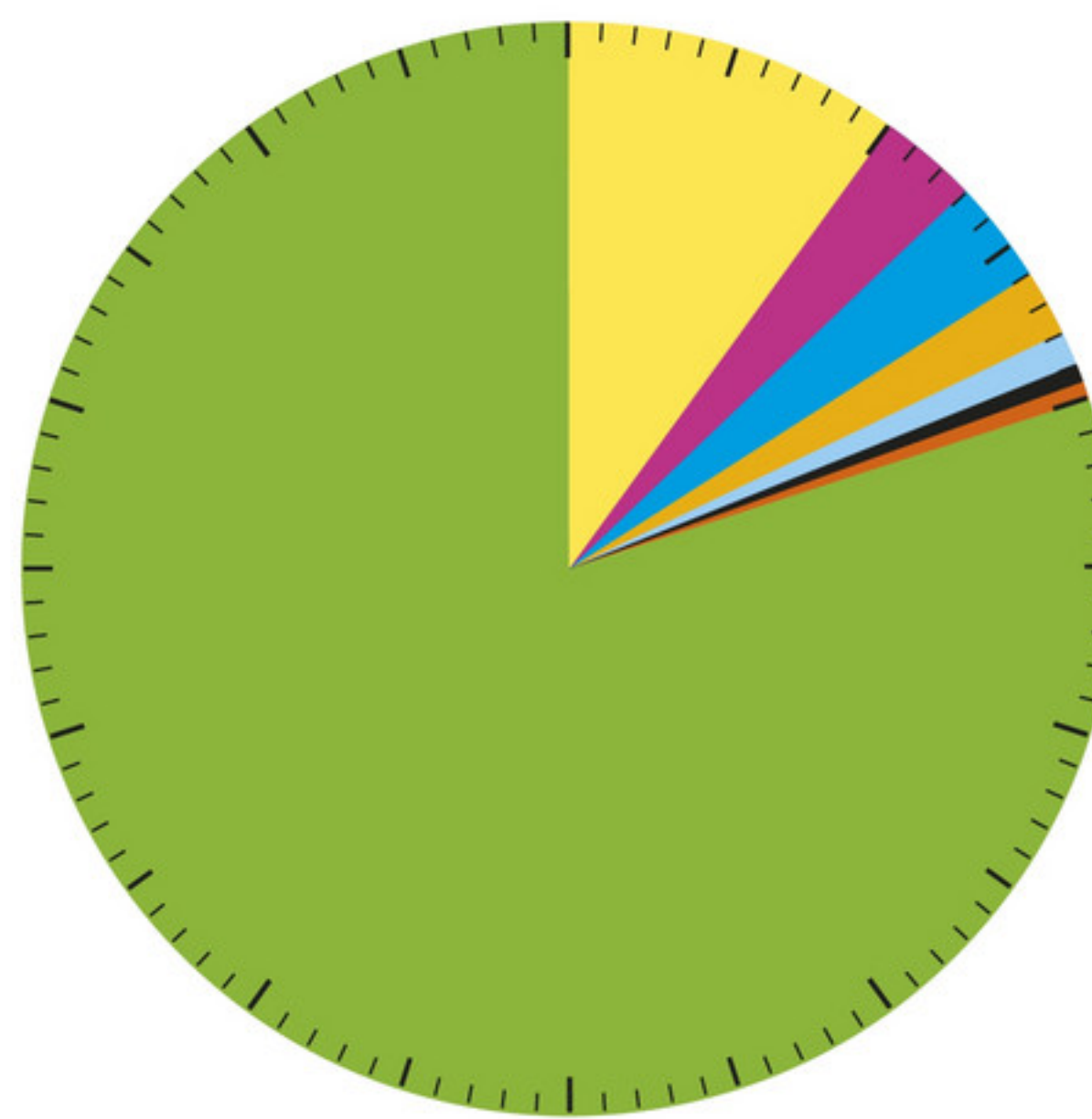
▼ **Fig. 54** Insect body structure.



There are lots of arthropod species. Figure 55 shows two pie charts. One gives the numbers of different species in the various phyla of the animal kingdom and the other shows the numbers of species within the arthropod groups.

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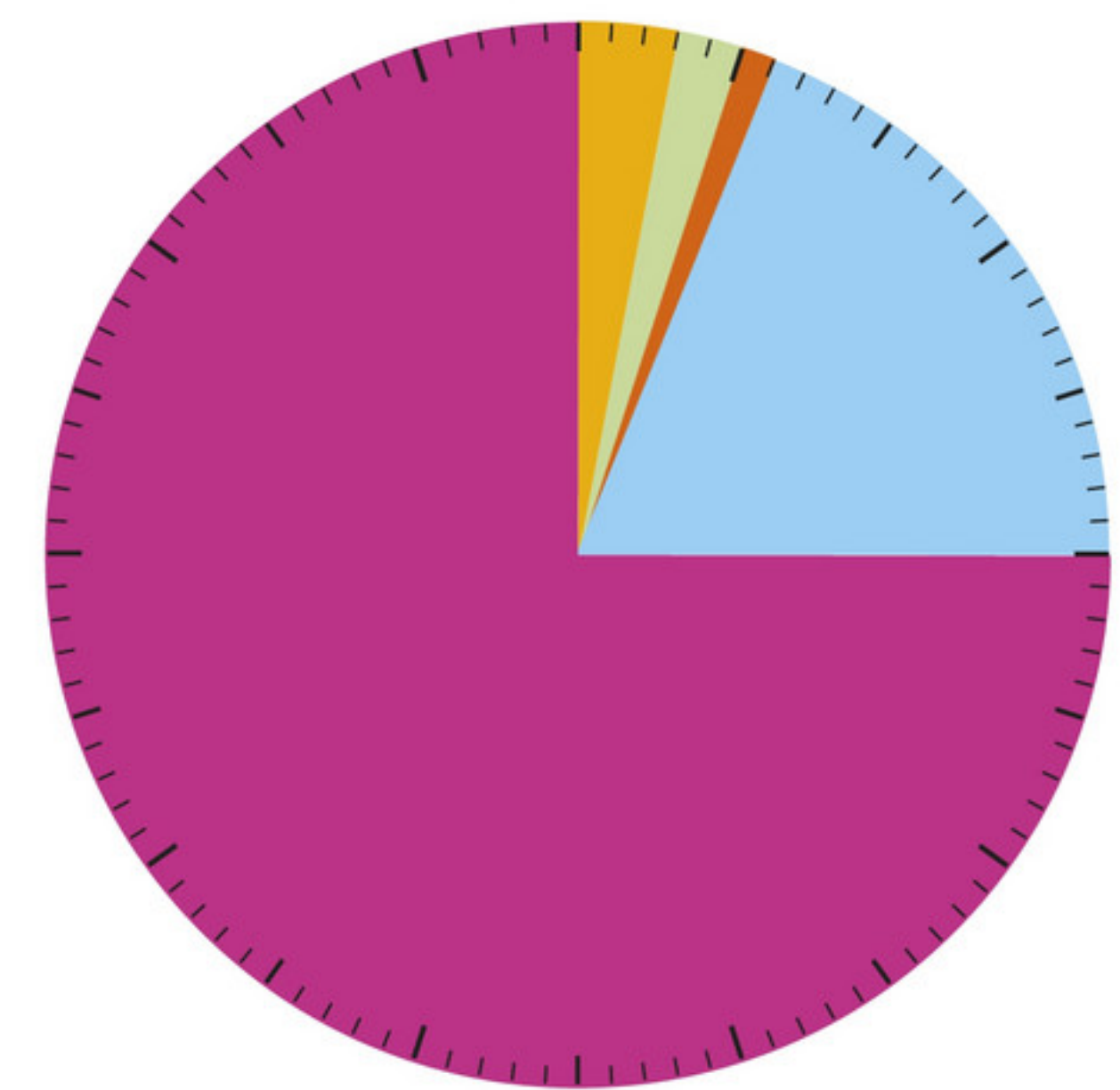
▼ **Fig. 55** Numbers of species in each phylum of the animal kingdom and in various groups of arthropods.



Legend:

- arthropods
- molluscs
- vertebrates
- worms
- echinoderms
- cnidarians
- sponges
- other animals

1 per phylum of the animal kingdom



Legend:

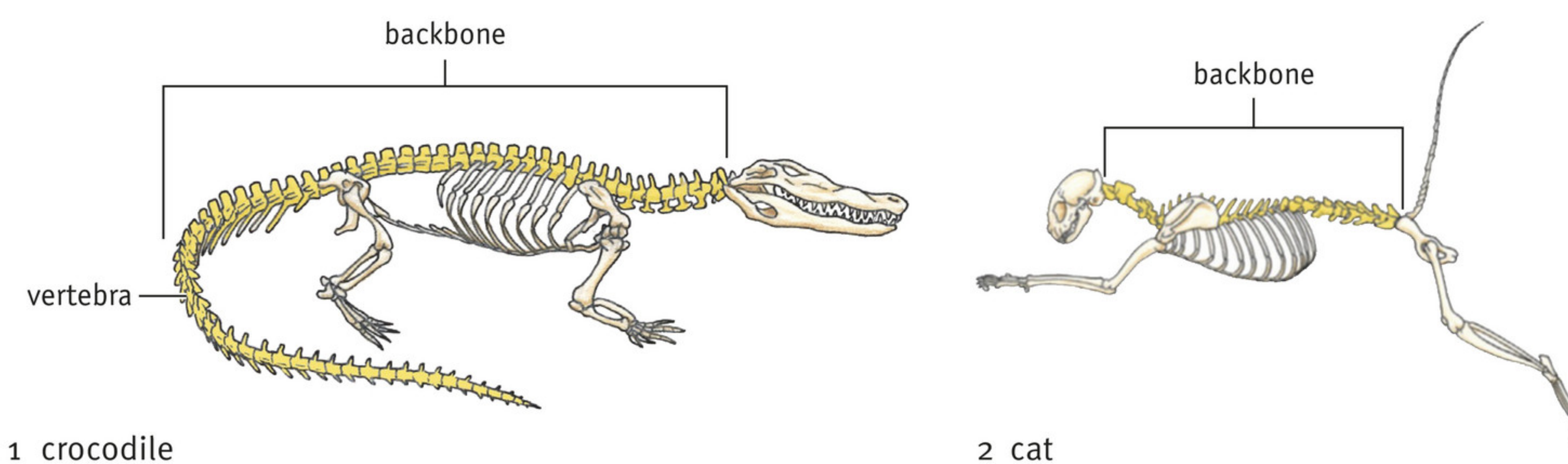
- insects
- arachnids
- crustaceans
- myriapods
- other classes

2 per group of the arthropod phylum

9 The vertebrate phylum

Vertebrates have an **endoskeleton**. Part of this internal skeleton is the **backbone**, which is made up of **vertebrae** (see figure 56). The vertebrate phylum is subdivided into classes. We shall be looking at five classes here: **fishes**, **amphibians**, **reptiles**, **birds** and **mammals** (see figure 60 on page 144).

▼ **Fig. 56** Vertebrates have a backbone with vertebrae.



FEATURES OF VERTEBRATES

The five classes of vertebrates can be distinguished using the following features:

- 1 The **skin**. In vertebrates, the skin is covered with scales, slime, feathers or hair.
- 2 The **body temperature**. In **warm-blooded animals**, the body temperature is constant (always the same). In **cold-blooded animals**, the temperature of the body is the same as the temperature of the surroundings. The body temperature is therefore not constant.
- 3 The **respiratory organs**. Vertebrates may breathe using gills or lungs. Some vertebrates can also breathe through their skin.
- 4 The **method of reproduction**. Many vertebrates lay eggs. There are eggs with no shells, eggs with hard calcium carbonate shells, and eggs with tough leathery shells (see figure 57).

▼ **Fig. 57** Eggs of vertebrates.



1 eggs with no shell, from a frog (frogspawn)

2 eggs with a leathery shell, from a snake

3 eggs with a calcium carbonate shell, from a blackbird

In some vertebrates, the young do not hatch out of eggs but are born directly from the mother. These are known as **viviparous** animals (see figure 58). The young drink (**suckle**) from the mother.

- 5 The **environment** (the surroundings or habitat) where the animals primarily live. There are vertebrates that live in the water. Others live on the land or in the air. Some vertebrates can live both on land and in the water. There are some exceptions too. For instance, virtually all mammal species live (primarily) on land. But there are some mammals that live in the water (see figure 59).

Figure 61 shows you some examples of vertebrate animals.

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▼ **Fig. 58** A dolphin is viviparous (has live young).



▼ **Fig. 59** Mammals that live in the water are an exception.



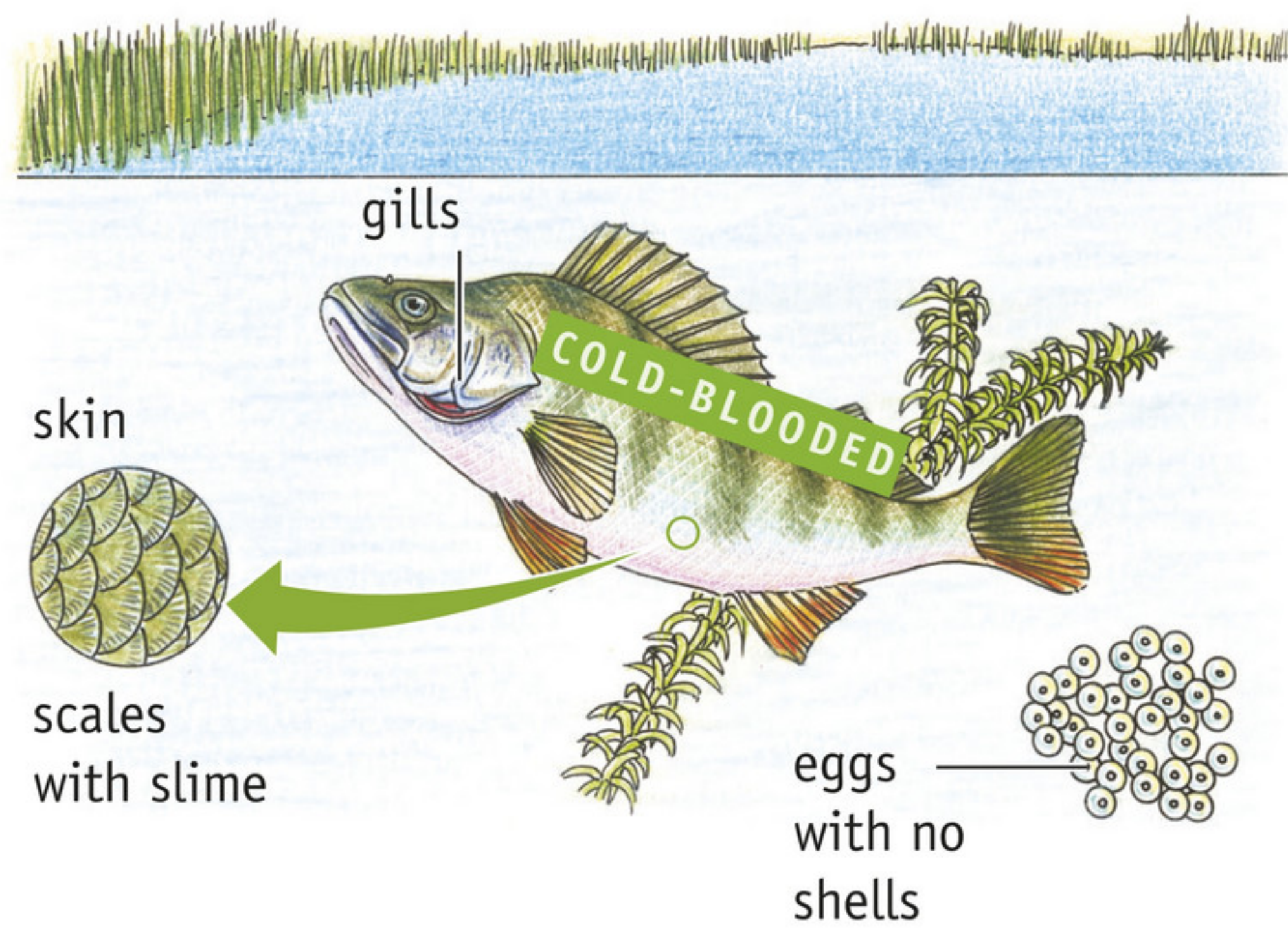
1 whale



2 seal

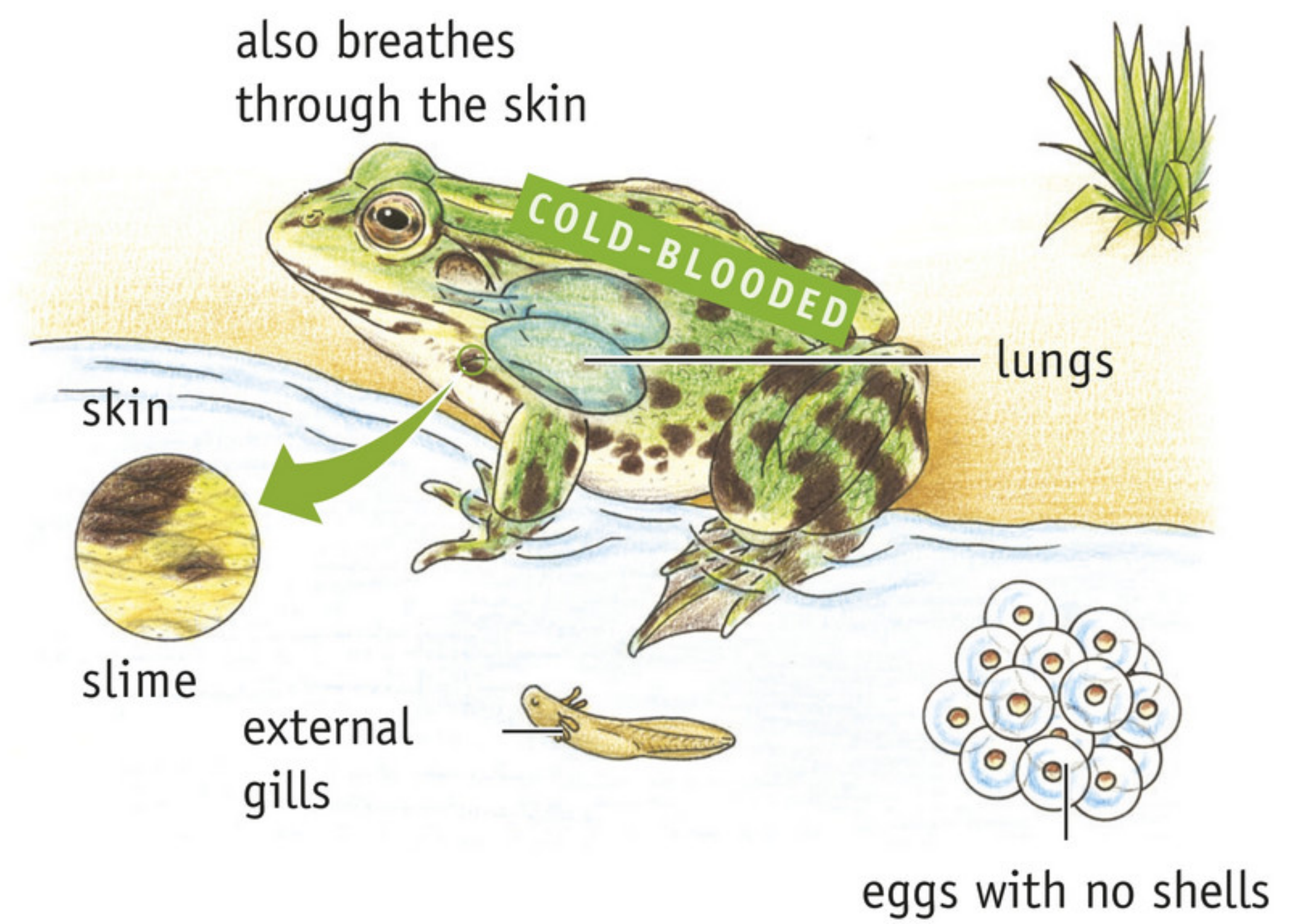
▼ Fig. 60 Features of vertebrates.

1 FISHES



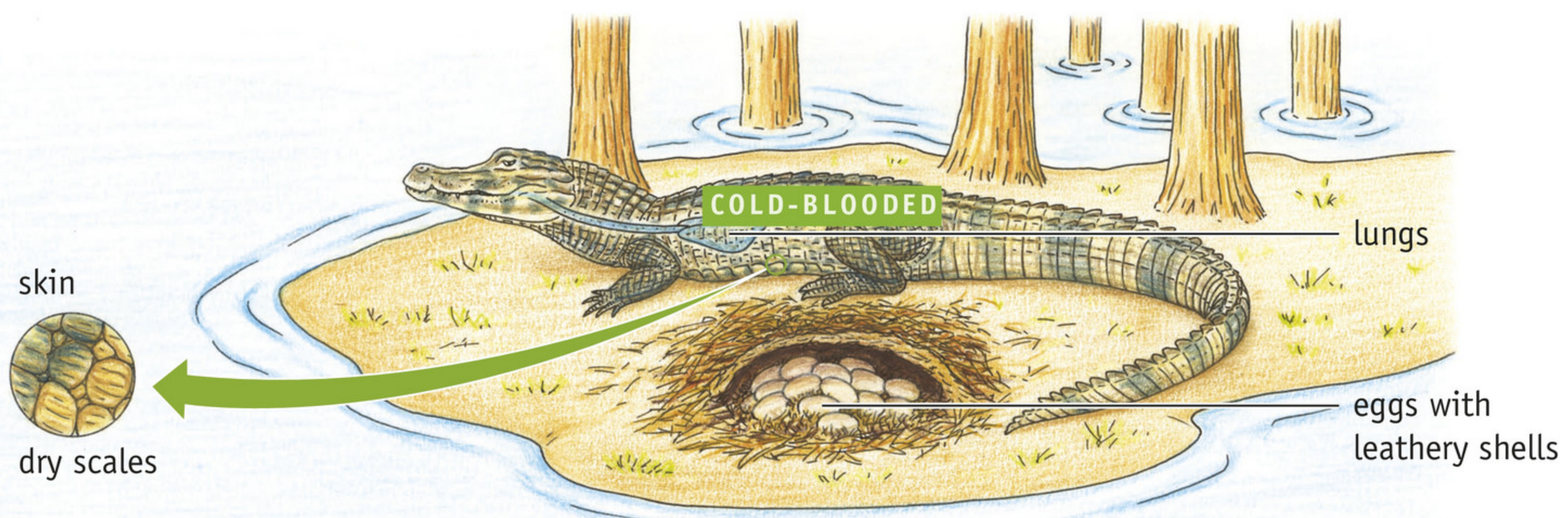
PERCH

2 AMPHIBIANS



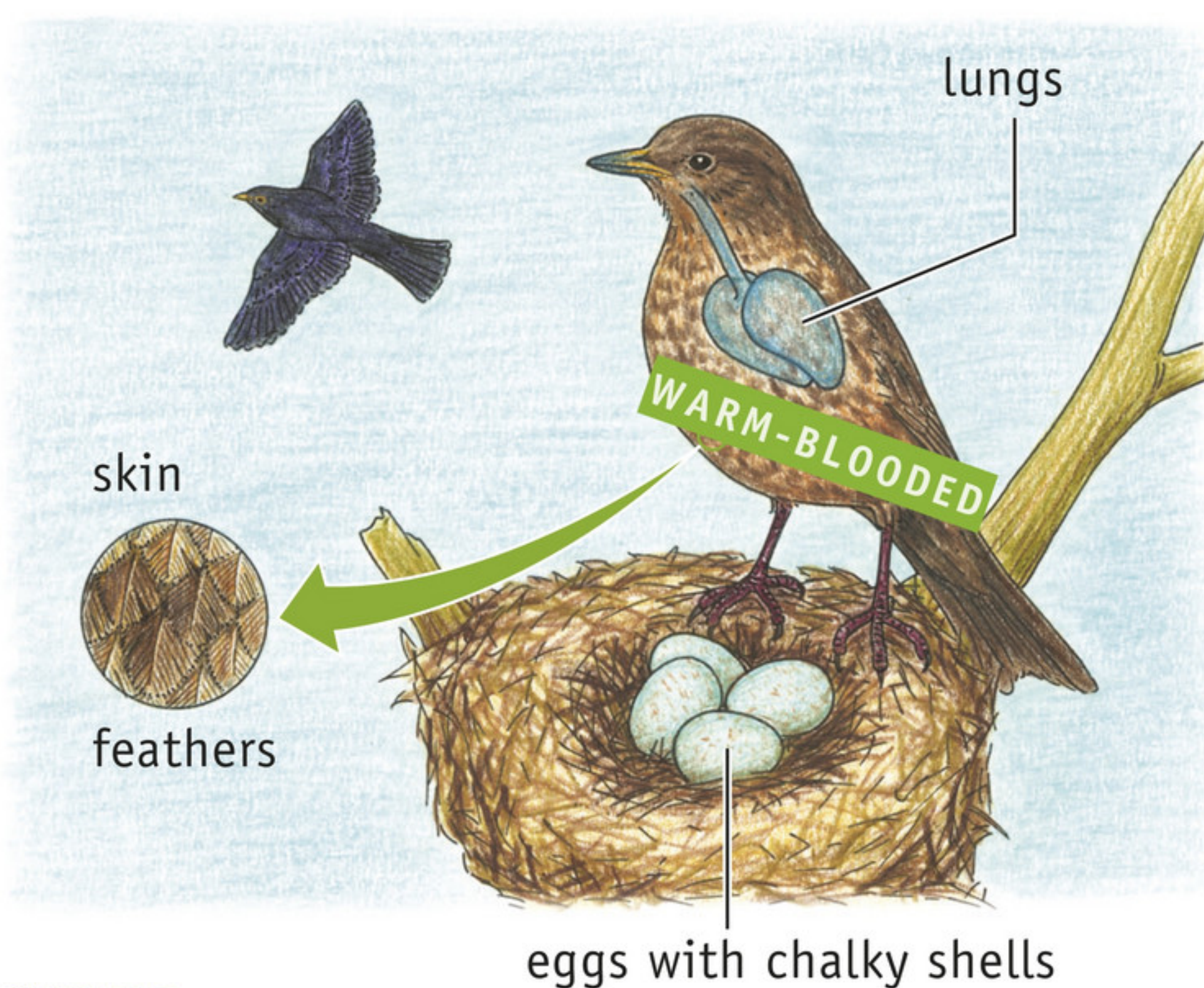
FROG

3 REPTILES



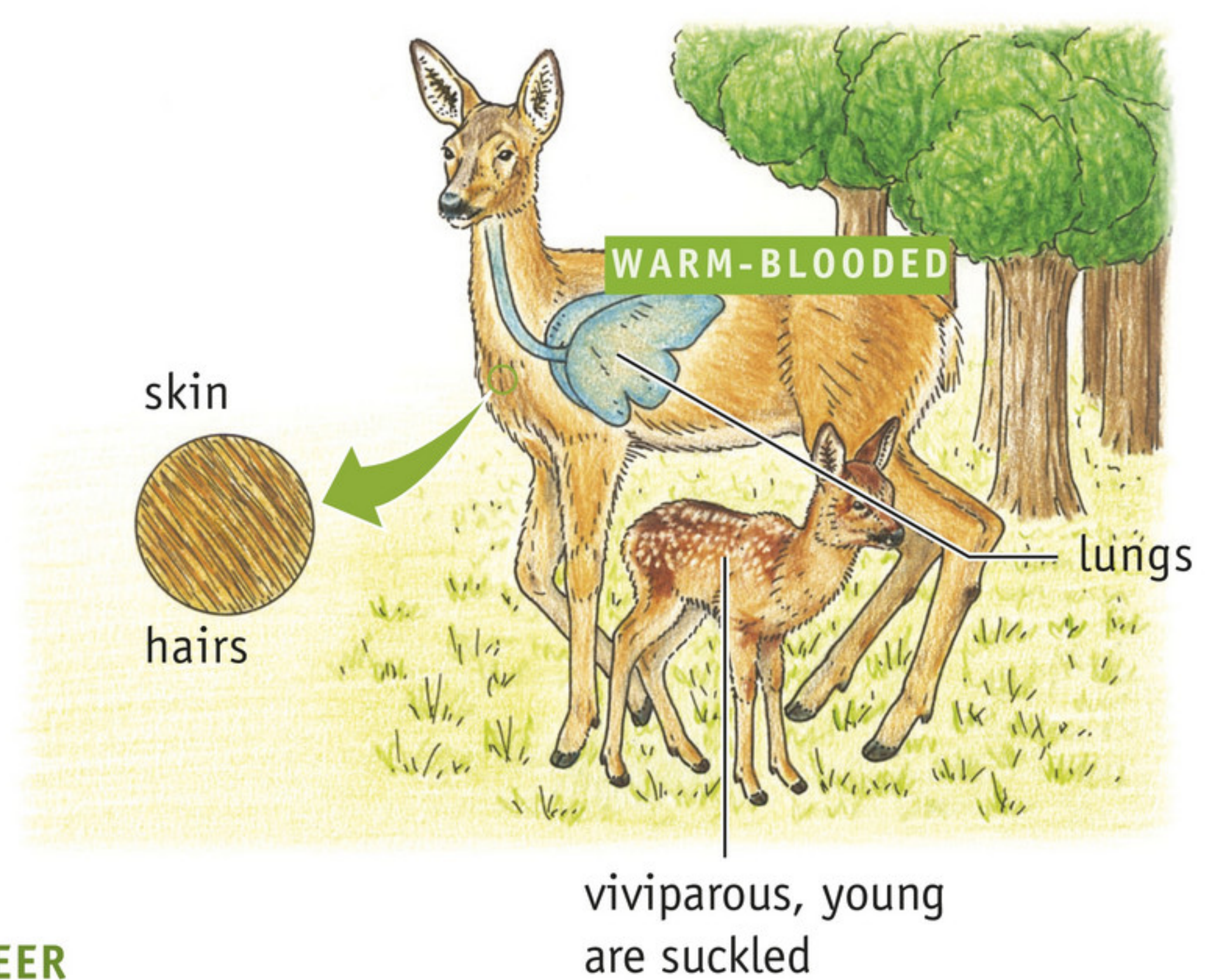
CROCODILE

4 BIRDS



BLACKBIRD

5 MAMMALS



DEER

▼ Fig. 61 Vertebrates in the Netherlands.



1 buzzard



2 magpie



3 trout



4 grebe



5 cod



6 toad



7 newt



8 plaice



9 shrew



10 falcon



11 roach



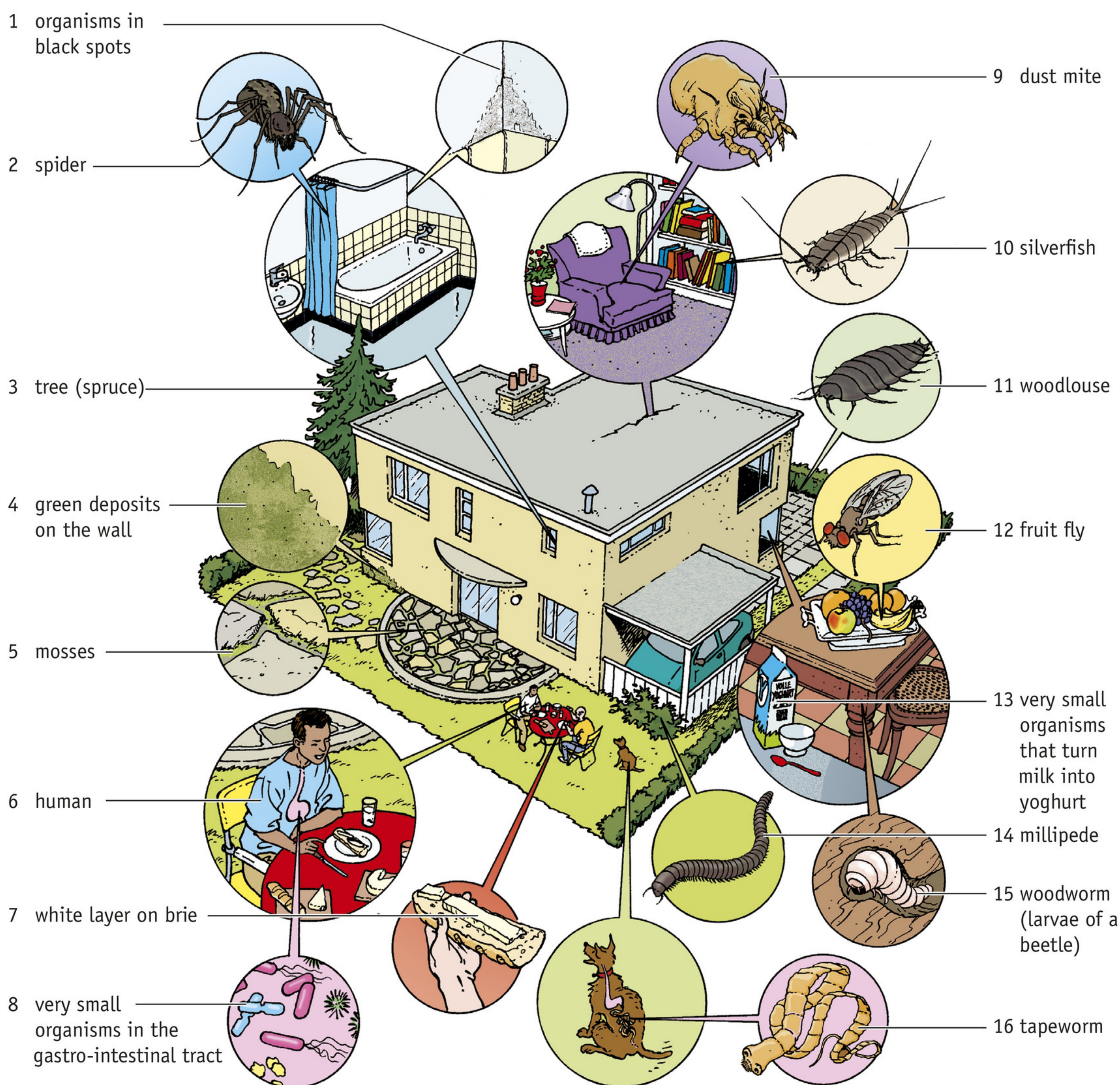
12 weasel

10 Identifying organisms

You have learned that we classify organisms into kingdoms, phyla, classes and various other smaller groupings. Figure 62 shows you a house and garden with living organisms in it. You are going to classify those organisms.

WB EXERCISE 42, PAGE 135

▼ Fig. 62



IDENTIFICATION

Organisms that you do not know can still be classified into a kingdom or phylum or other group by looking at their characteristics. We call this **identification**. As an example, let's take a white deadnettle (see figure 63). You can identify this organism using an **identification table** (see figure 64), also known as a **key**. If you want to identify an organism, start at number 1. Next to number 1 in the identification table, you see:

▼ **Fig. 63** White deadnettle.



- | | |
|---|--|
| 1 | a The organism has chloroplasts plants , continue from 4
b The organism does not have chloroplasts continue from 2 |
|---|--|

The white deadnettle has chloroplasts, so it is a **plant**. That means you have to continue from 4. There are two possibilities there:

- | | |
|---|--|
| 4 | a The plant has roots, stems and leaves continue from 5
b The plant does not have roots, stems or leaves algae |
|---|--|

The white deadnettle does have roots, a stem and leaves, so you have to continue from 5. There are two possibilities there:

- | | |
|---|--|
| 5 | a The plant does not have flowers; it reproduces through spores spore-bearing plants
b The plant has flowers; it reproduces through seeds seed plants |
|---|--|

The white deadnettle has flowers and it reproduces through seeds, and so it must be a **seed-bearing plant**.

A white deadnettle is therefore a member of the **plant kingdom** and the phylum of **seed-bearing plants**.

You should also note down the steps that you take as you go through the identification table. For the white deadnettle, it was **1a – 4a – 5b**.

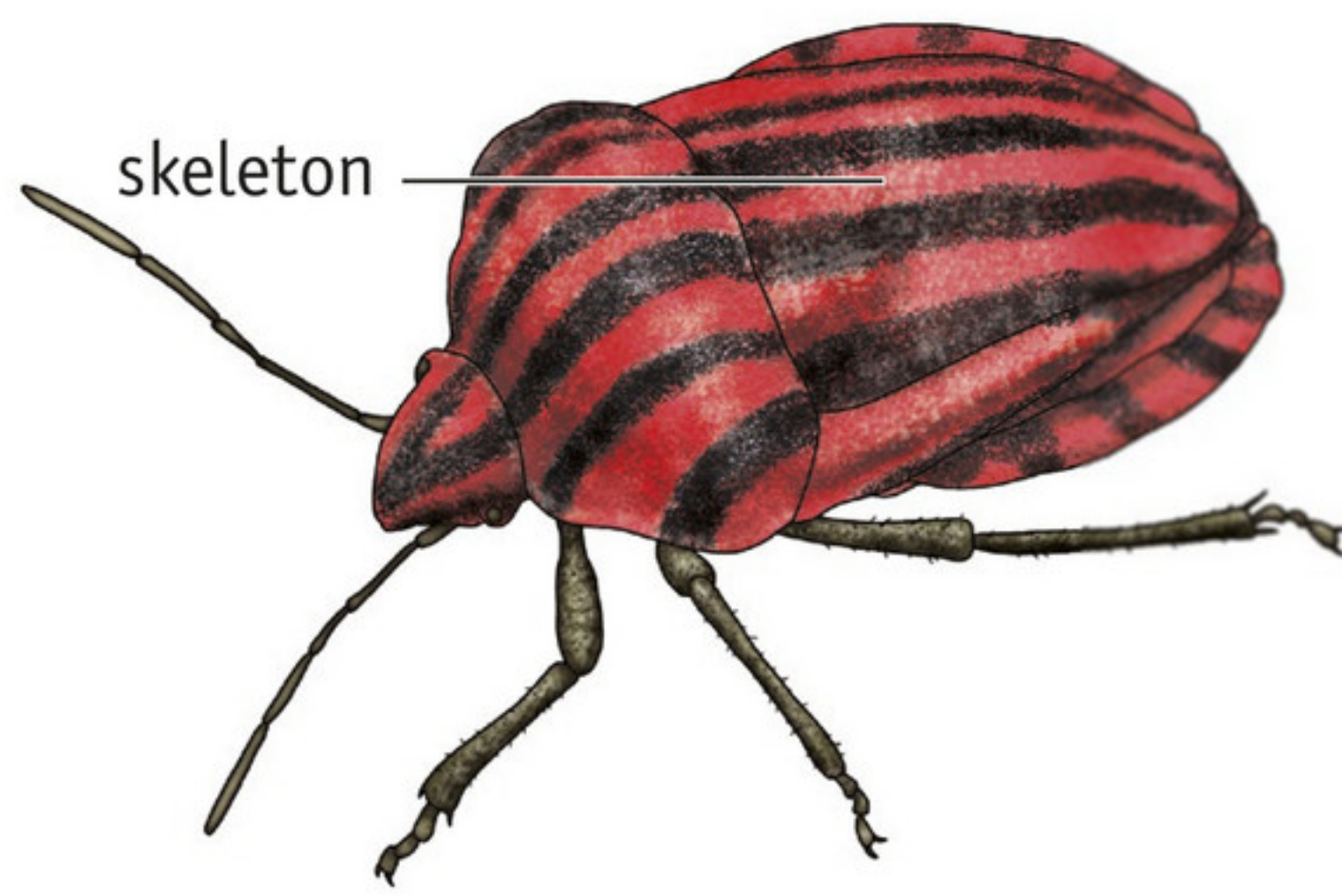
WB EXERCISES 43 AND 44, PAGE 135

▼ Fig. 64

IDENTIFICATION TABLE

1 a	The organism has chloroplasts	plants , continue from 4
b	The organism does not have chloroplasts	continue from 2
2 a	The organism has a cell wall around each cell	continue from 3
b	The organism does not have cell walls	continue from 6
3 a	The organism has no nucleus and it is single-celled	bacteria
b	The organism has a nucleus in every cell	fungi
4 a	The plant has roots, stems and leaves	continue from 5
b	The plant does not have roots, stems or leaves	algae
5 a	The plant does not have flowers; it reproduces through spores	spore-bearing plants
b	The plant has flowers; it reproduces through seeds	seed-bearing plants
6 a	The organism is asymmetrical	continue from 7
b	The organism is symmetrical	animals , continue from 8
7 a	The organism is single-celled	other unicellular eukaryotes
b	The organism is multicellular	sponges (belong to the animal kingdom)
8 a	The animal is radially symmetrical	continue from 9
b	The animal is bilaterally symmetrical	continue from 10
9 a	The animal has no skeleton but does have tentacles	cnidarians
b	The animal has an internal skeleton and the skin is covered in spines or nodules	echinoderms
10 a	The animal has no skeleton and the body is long and thin	worms
b	The animal has a skeleton	continue from 11
11 a	The animal's skeleton is a shell	molluscs
b	The animal's skeleton is not a shell	continue from 12
12 a	The animal has an external skeleton (exoskeleton)	arthropods , continue from 13
b	The animal has an internal skeleton with a backbone	vertebrates , continue from 16
13 a	The body is made up entirely of segments	myriapods
b	The body is not entirely made up of segments	continue from 14
14 a	The animal has ten or more legs	crustaceans
b	The animal has fewer than ten legs	continue from 15
15 a	The animal has eight legs	arachnids
b	The animal has six legs	insects
16 a	The skin of the animal is covered in scales	continue from 17
b	The skin of the animal is not covered in scales	continue from 18
17 a	The scales are covered in slime and the animal uses gills to breathe	fishes
b	The scales are dry (not covered in slime) and the animal uses lungs to breathe	reptiles
18 a	The skin of the animal is covered in slime	amphibians
b	The skin of the animal is not covered in slime	continue from 19
19 a	The skin of the animal is covered in feathers	birds
b	The skin of the animal is covered in hairs	mammals

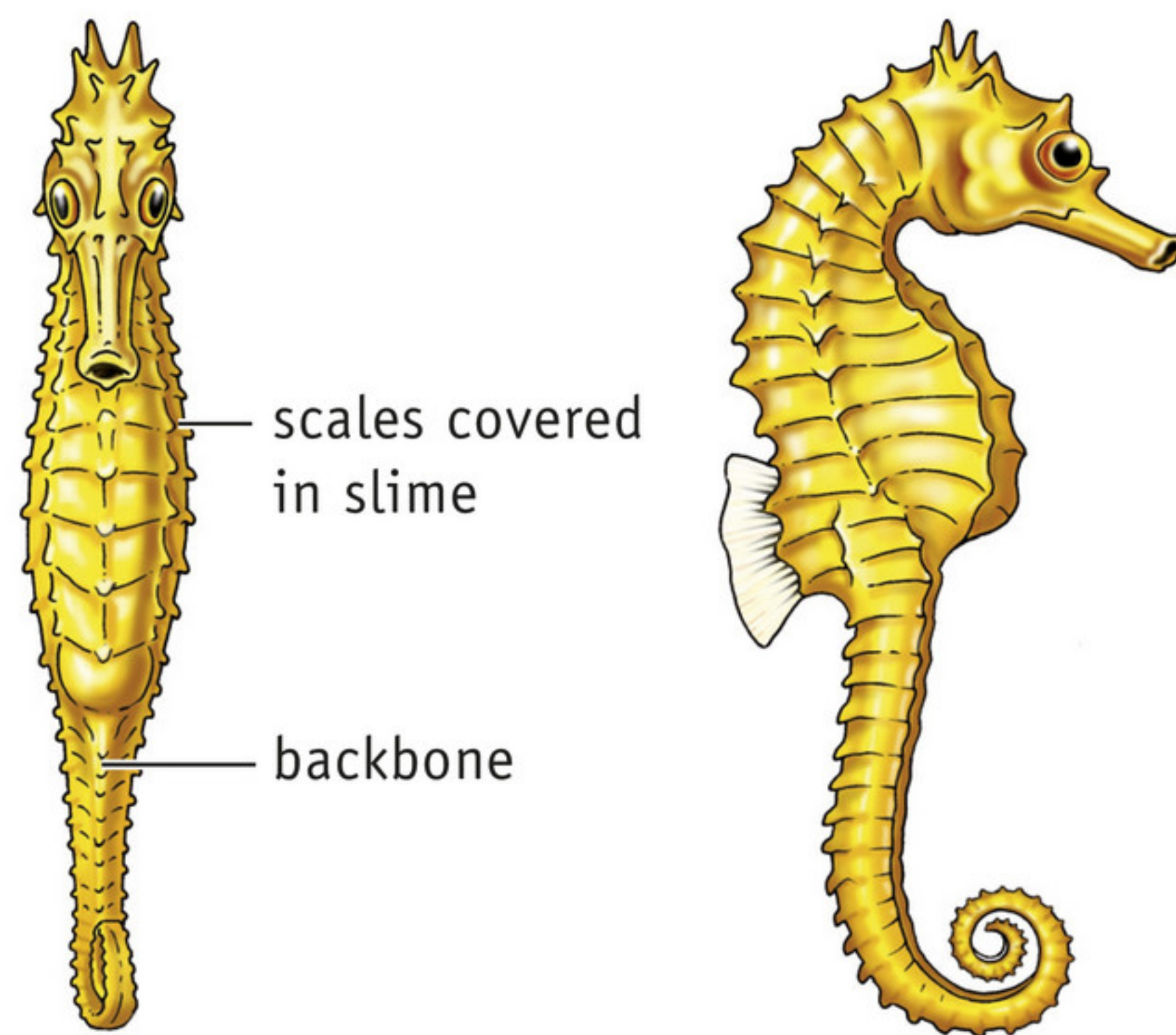
▼ Fig. 65



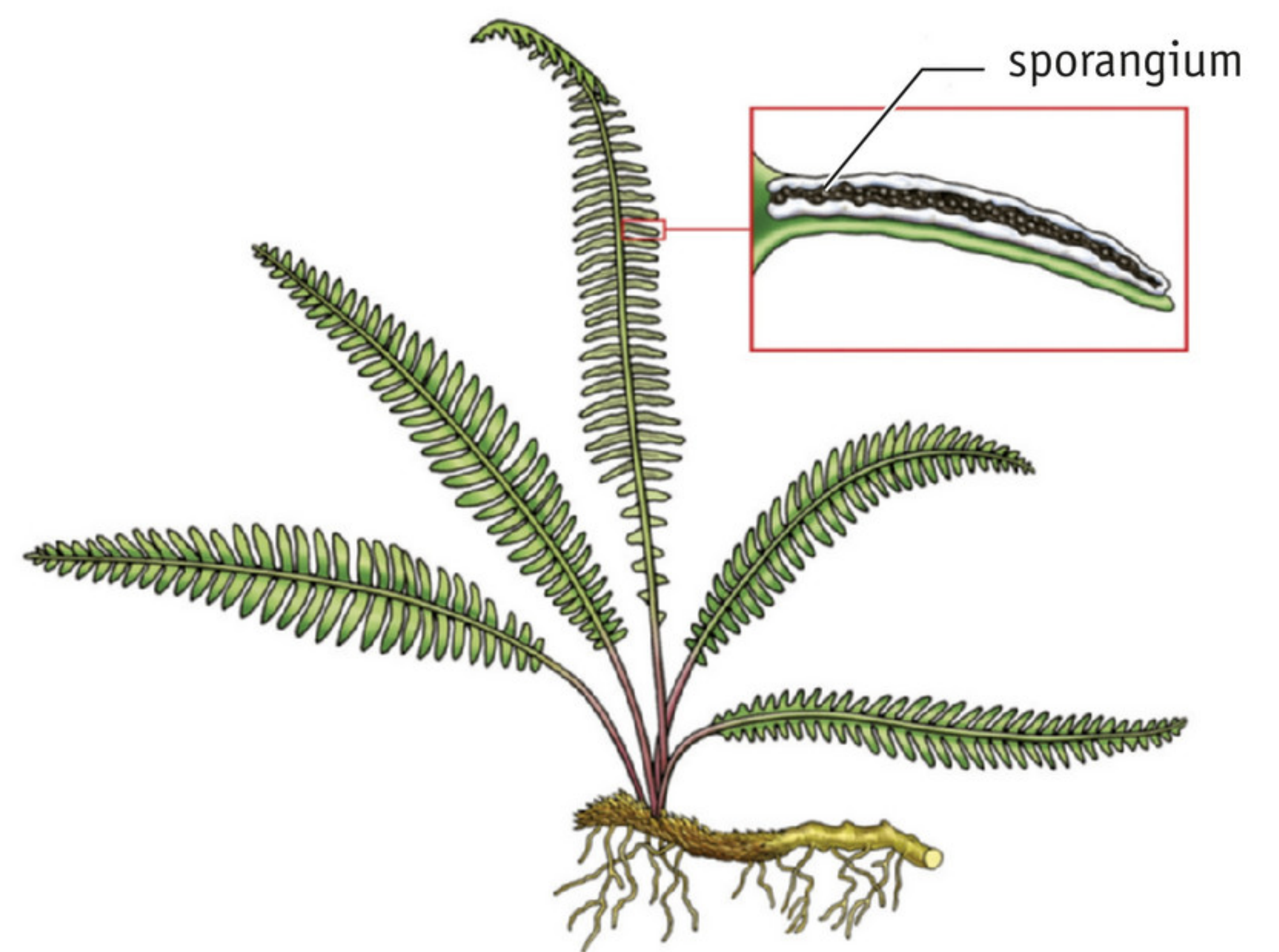
1 striped shield beetle



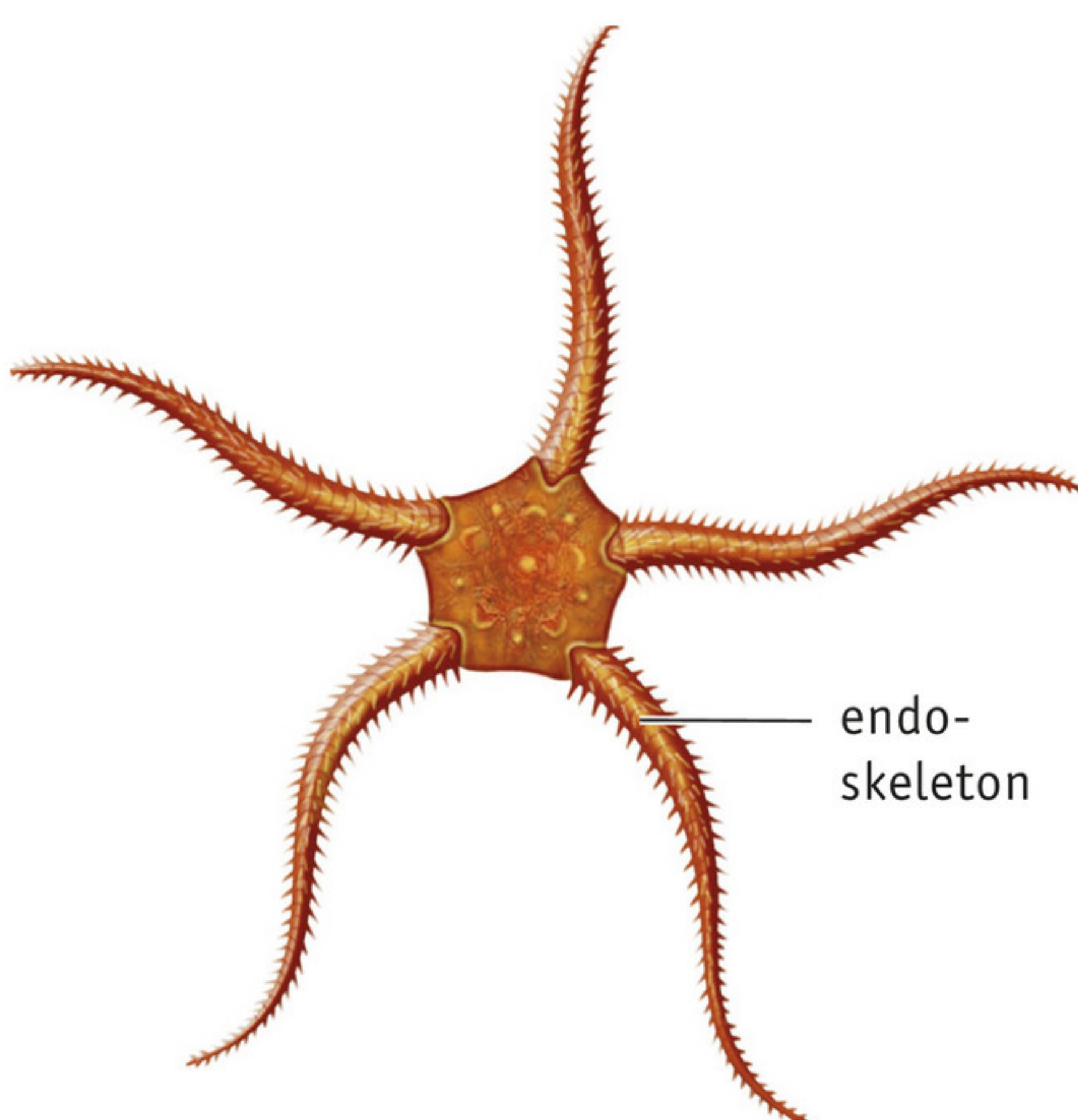
2 porcini



3 seahorse



4 deer fern



5 brittle star



6 white clover

11 Animal project

In this basic material, you are going to do a project about an animal or a group of animals. In figure 66, you can read about the things you must take care with when doing this written schoolwork.

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▼ **Fig. 67** A title page for written schoolwork.



▼ **Fig. 68** A table of contents for a written schoolwork project.

Table of contents	
	page
Introduction	3
Classification	4
Other species	6
Extinct species	8
Habitat	9
Food	10
Natural enemies	12



▼ **Fig. 66**

RULES FOR WRITTEN SCHOOLWORK

- 1 Your schoolwork project has to contain a number of pieces of information about your subject. Search for this information in reference works (books, magazines, CD-ROMs, the Internet). Note the data down on scrap paper.
- 2 Check whether you have collected all the information that you need for your schoolwork project. Put the data in a logical order.
- 3 Split the project up into short chapters. Each chapter has to have a title.
- 4 Find some pictures about your subject. You can also make drawings yourself.
- 5 You should preferably type the text on the computer. If that is not possible, write the texts for each chapter on pages of loose lined paper (for example paper for a ring binder). Alternate between text and pictures.
- 6 Make a nice title page. Write the name of the schoolwork project, your own name and your class on it (see figure 67).
- 7 Make a table of contents. This contains the titles of the chapters of the schoolwork project and the page that each of the chapters starts on (see figure 68).
- 8 Make an introduction for your project. This is where you can say why you did this particular schoolwork project.
- 9 Bind the loose pages together to make a single piece of work. After the title comes the table of contents first of all, and then the introduction.



12

Classifying seed-bearing plants

In the Basics, you learned that we divide the plant kingdom into the phyla of algae, spore-bearing plants and seed plants. The phylum of seed-bearing plants can be divided further into **conifers** and **flowering plants**.

In **conifers** (gymnosperms, which literally means ‘naked seeds’), the seeds can be found between the scales of the **cones** (see figure 69). You have probably come across the cones of firs and spruces in woods. If the scales are open, the seeds can then be found uncovered in between the scales. The leaves of most conifers are **needles**. All needle-bearing trees, such as the pine and the spruce, are conifers.

In **flowering plants** (angiosperms), the seeds are inside **fruits** (see figure 70). The seeds are covered by the fruits. Examples of fruits are apples, pears, berries and pods. The fruits can be difficult to see in some flowering plants. All deciduous trees and shrubs, as well as herbaceous plants such as a dandelion, are flowering plants.

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▼ **Fig. 69** Conifers.



1 fir trees



2 the seeds are found uncovered between the scales of the cone

▼ **Fig. 70** Flowering plants.



1 cherry tree



2 the seeds are covered with a fruit

13

Practical assessment: The mussel

In this extra material, you are going to look at the structure of a mussel.

WHAT DO YOU NEED?

- a saltwater mussel (boiled briefly) in a dish
- a scalpel (see figure 71) or a blade
- scissors
- drawing paper and drawing materials

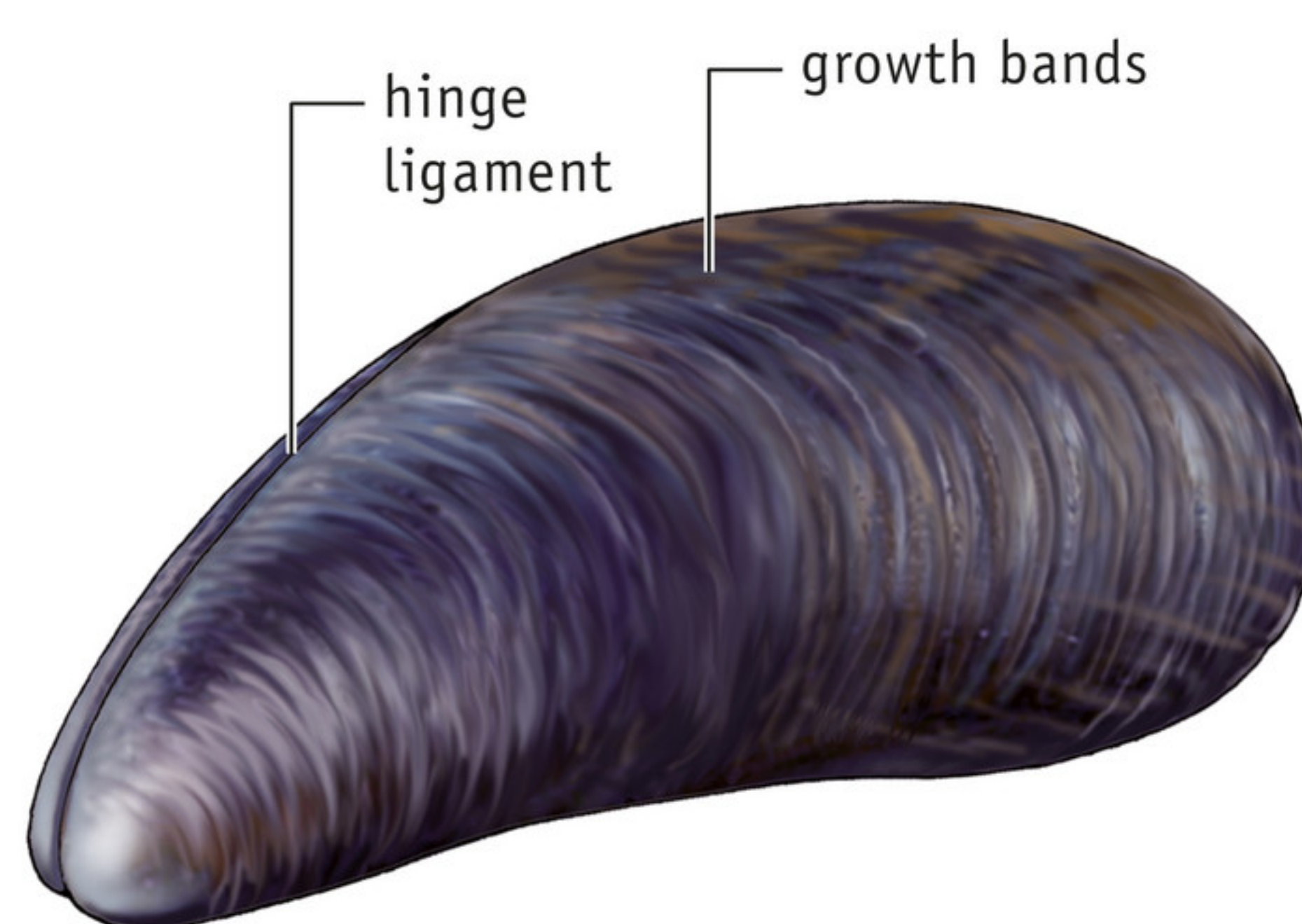
▼ Fig. 71 Scalpel.



WHAT DO YOU HAVE TO DO?

- Put the mussel down in front of you. The mussel is covered by two **shells** that fit tightly together. You can see **growth bands** on the shells (see figure 72). The two shells are hinged together by the **hinge ligament** that holds the two shells in place.
- Draw the external view of the mussel. Place the mussel so that you can see the hinge ligament and one of the shells. Draw accurately how the growth bands run across the shell. Label the following parts: *hinge ligament* – *growth band*– *shell*.

▼ Fig. 72 Mussel (external view).

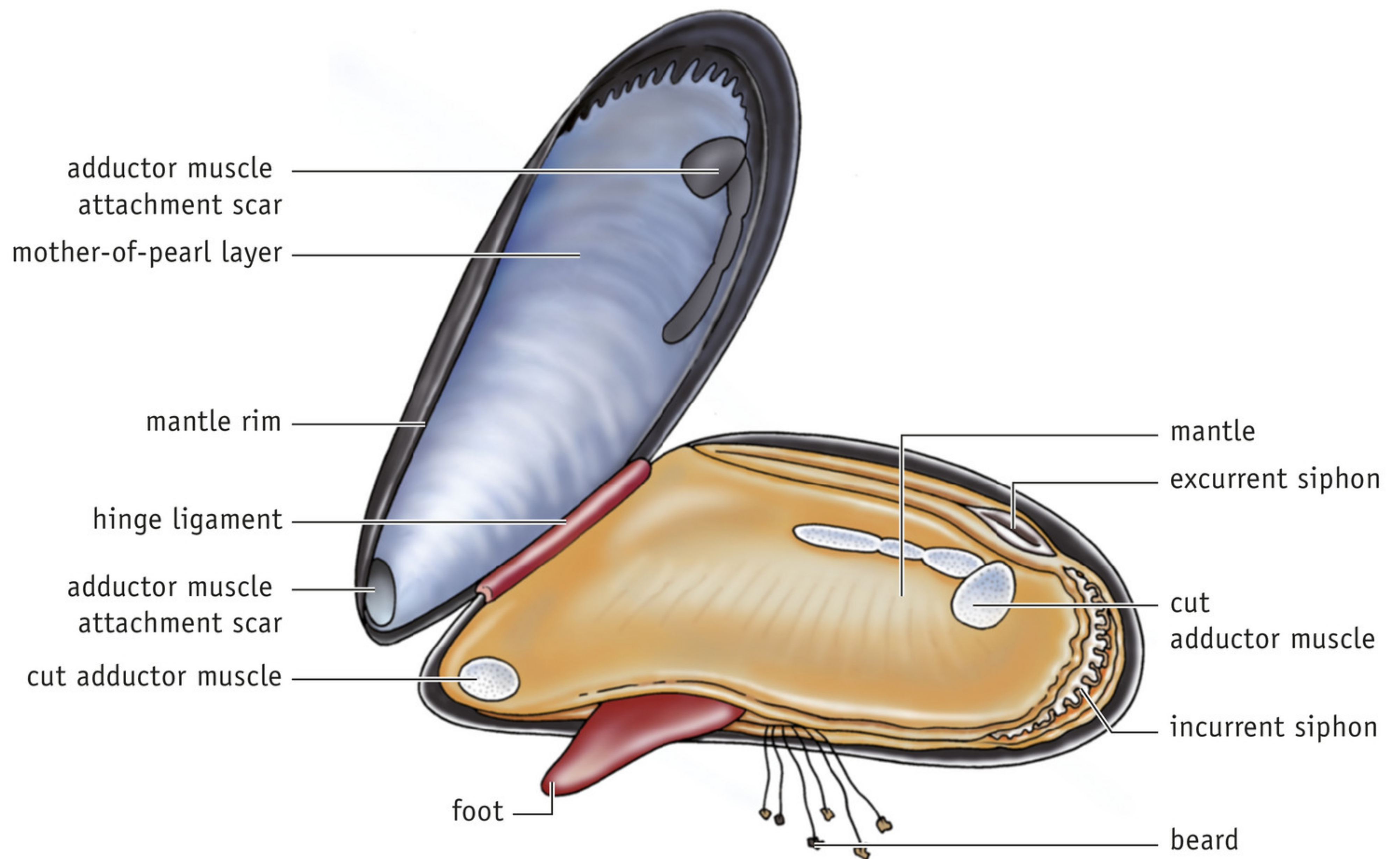


- The body of the mussel has two **adductor muscles** (see figure 73). These are what pull the two halves of the shell tightly closed. When the adductor muscles relax, the elasticity of the hinge ligament makes the two shells spring open.

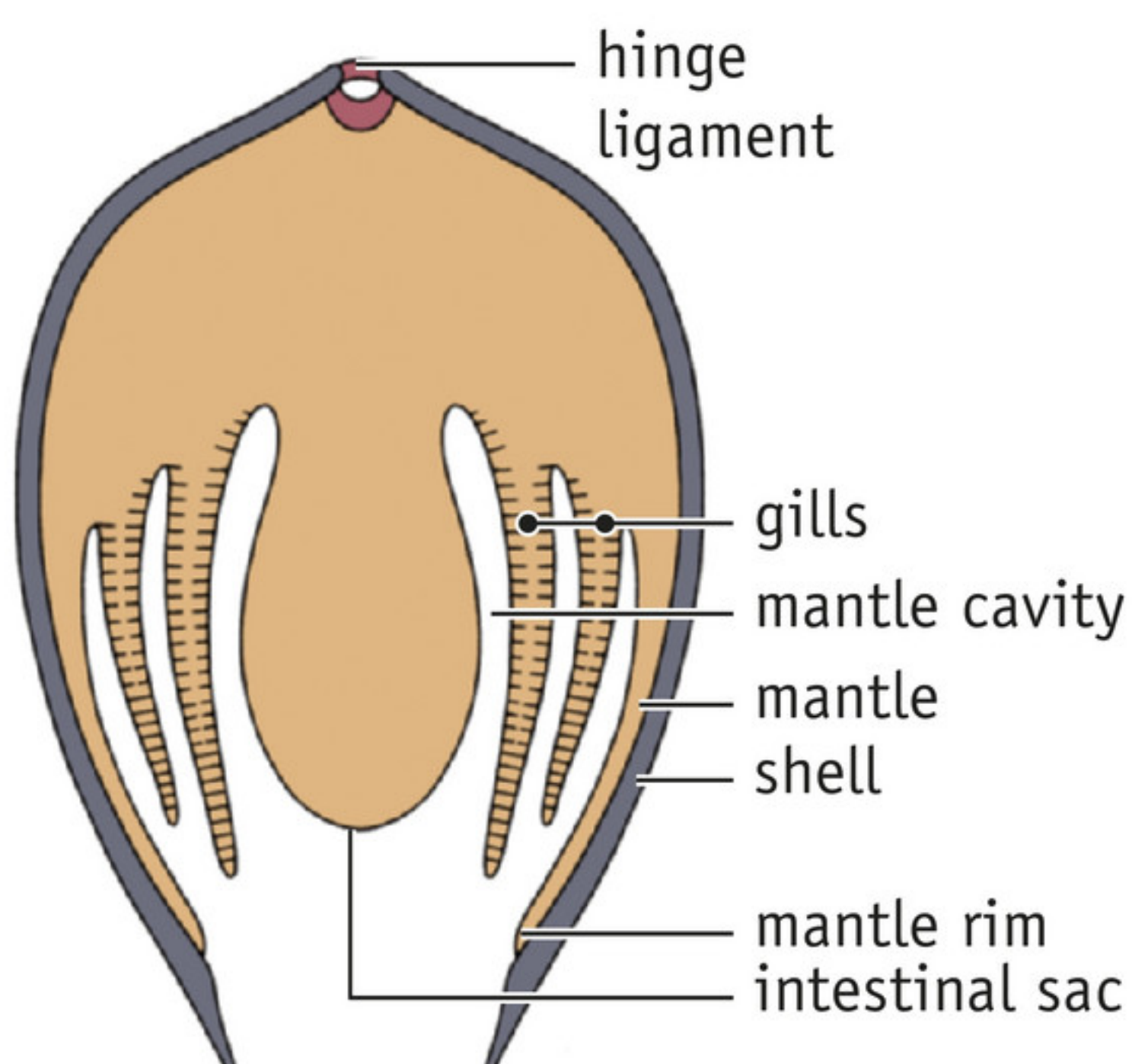
The **mantle** is up against both the shells (see figure 74).

Boiling the mussel has probably already made it come away from one of the shells. Use the scalpel or blade to cut the mussel away entirely from the top shell. To do this, you have to cut through both adductor muscles. Then fold the shell open (see figure 73).

▼ **Fig. 73** Mussel with shell open.



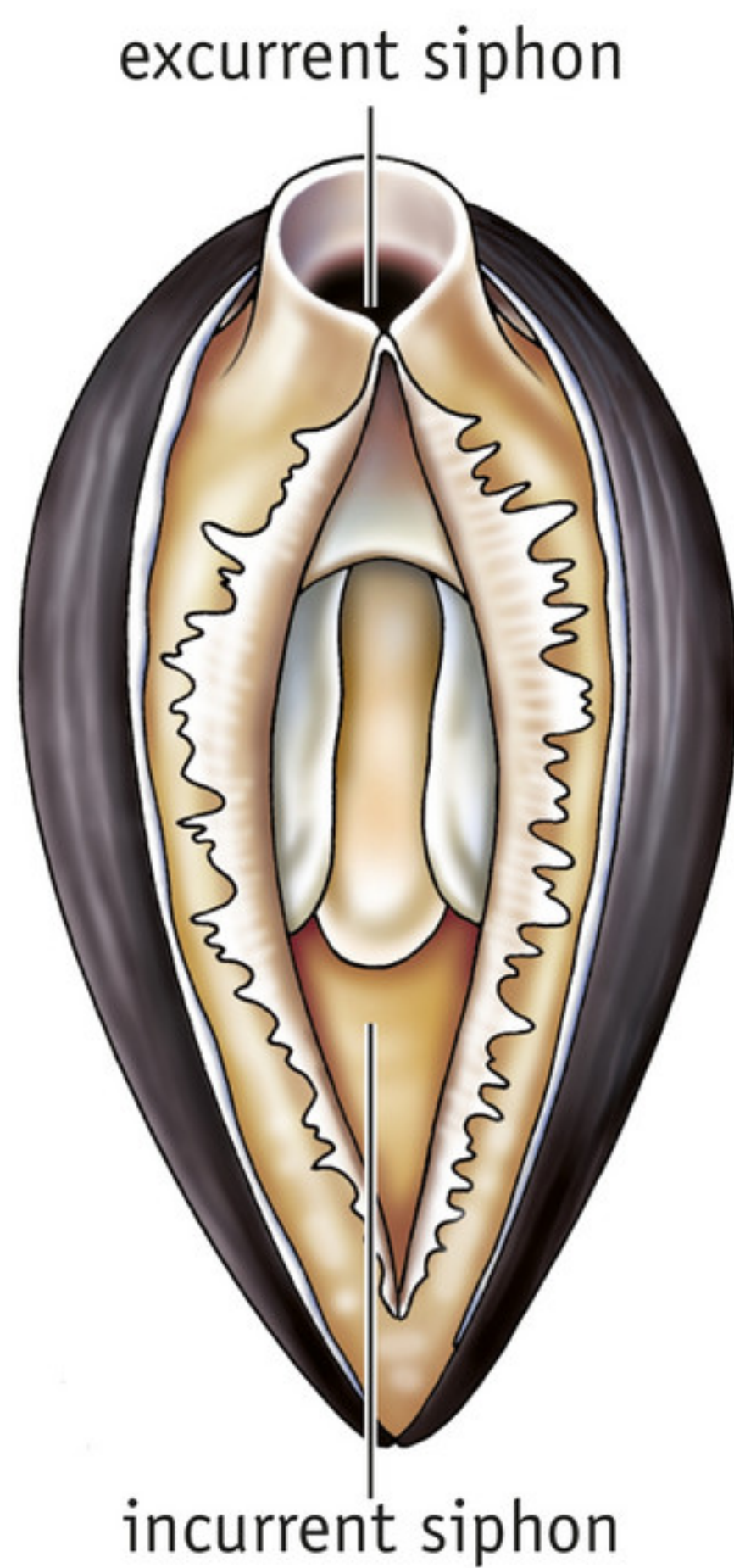
▼ **Fig. 74** Cross section of a mussel (schematic).



In the opened shell, you can see the **attachment scars of the adductor muscles** and the **mother-of-pearl layer** (see figure 73). You will also be able to see the **mantle rim**. That is the outer edge of the pearly layer. This is where the mantle was attached.

- Make a drawing of the opened shell (the shell that the mussel is not in). Label the following parts: *adductor muscle attachment scar* (2×) – *mantle rim* – *pearly layer*.
- Remove the opened shell. Examine the other shell (with the mussel). You can see the mantle and the cut adductor muscles (see figure 73). The **foot** may be sticking out from under the mantle. A mussel can use its foot to move slowly. In saltwater mussels, the foot is generally small.
- A saltwater mussel has a **beard** that holds it tightly in place. This beard is made of threads. Because these threads break off easily, you may not find any on the mussel you are examining.

▼ Fig. 75 Mussel, front view.



On one side of the mussel, there are two openings between the left and right halves of the mantle: the **incurrent siphon** and the **excurrent siphon** (see figure 73). Figure 75 shows you a front view of a mussel with the incurrent and excurrent siphons marked.

- Make a drawing of the mussel in the shell. Label the following parts: *beard* (if you can see one) – *cut adductor muscles* (2×) – *incurrent siphon* – *mantle* – *foot* (if this is sticking out from under the mantle).
- Lay the mussel down so that you are looking at the incurrent siphon and excurrent siphon from the front. Make a drawing of this. Label the following parts: *incurrent siphon* – *excurrent siphon*.

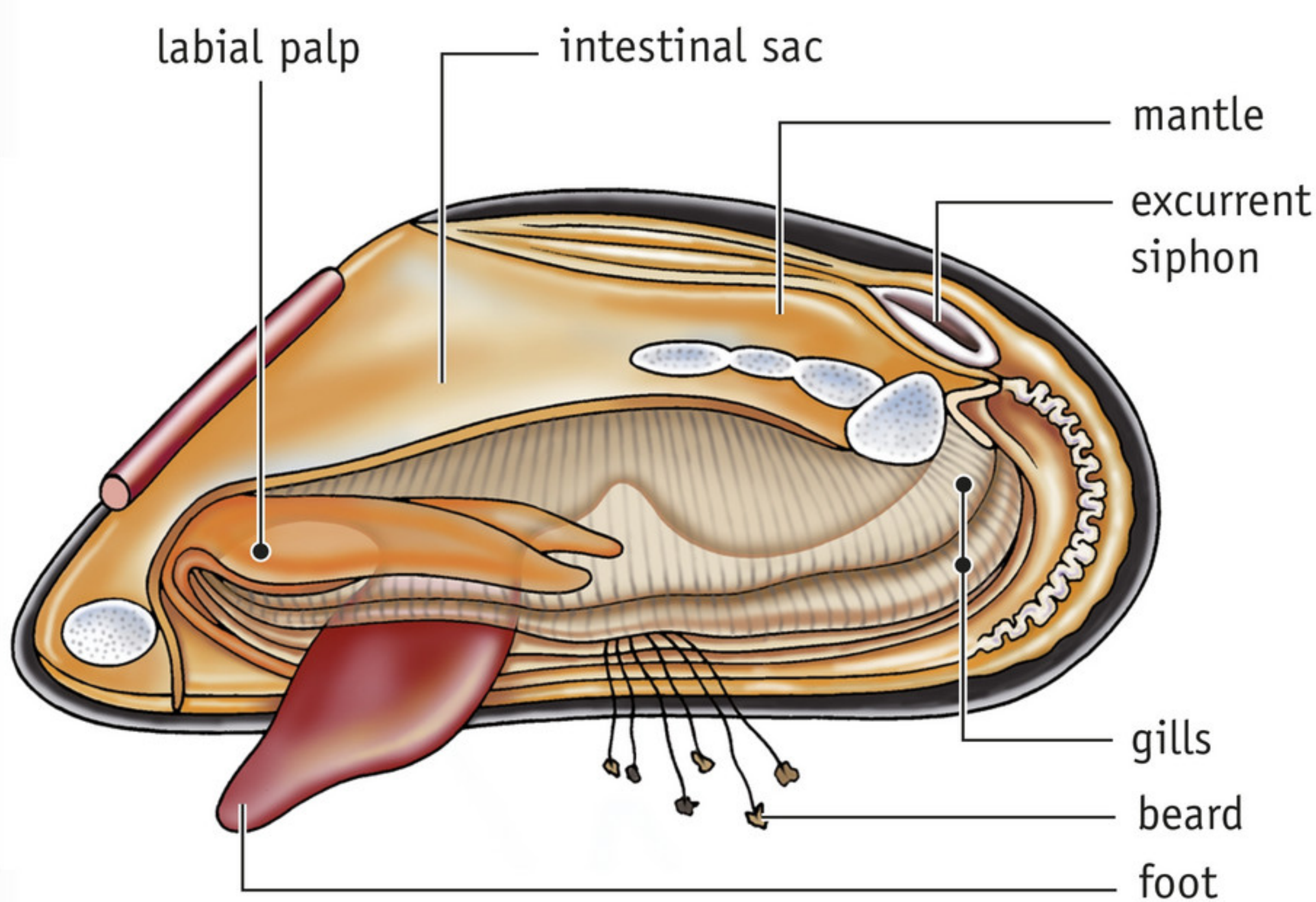
- Use the scissors to cut as much of the mantle away as possible, without damaging the underlying tissues (see figure 76). You will now definitely be able to see the foot and the (remains of) the beard. The **gills** can be seen as thin membranes in the mantle cavity (see figure 76). The boiling has probably made the gills shrink (a lot).

At the side by the foot, you can see the **labial palps** (see figure 76). The labial palps are located around the mouth. The mouth is difficult to see. The rest of the mussel is the **intestinal sac**.

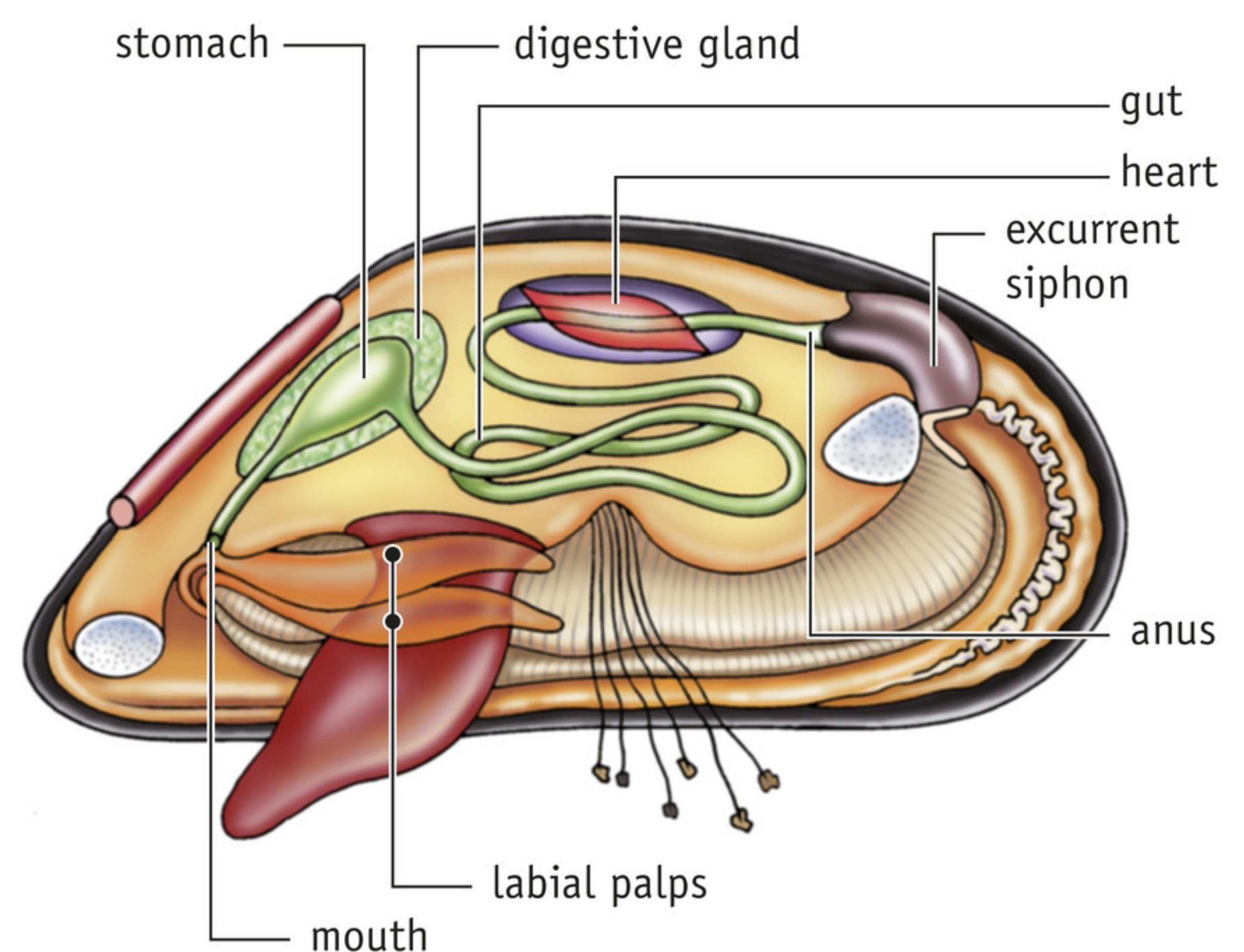
Draw the mussel with its mantle cut away. Label the following parts: *beard* – *intestinal sac* – *gills* – *labial palp* – *foot*.

Water containing oxygen and food flows into the incurrent siphon and past the gills and mouth. The gills absorb oxygen from the water. The food goes into the mouth. The labial palps help move it there. The anus is located close to the excurrent siphon (see figure 77). Water containing waste products leaves the mussel via the excurrent siphon. You cannot see a great deal of the rest of the internal structure. The digestive gland (see figure 77) is often greenish.

▼ Fig. 76 Mussel with the mantle cut away.



▼ Fig. 77 Internal structure of a mussel.



Summary

OBJECTIVE 1

You have to be able to classify organisms into the domains and kingdoms. You must be able to list the characteristics of cells from each domain and kingdom.

Domain	Kingdom	Cell features
Bacteria	–	– unicellular – no nucleus
Archaea	–	– cell wall – no chloroplasts
Eukaryotes	Fungi	– unicellular or multicellular – nucleus/nuclei – cell wall/walls – no chloroplasts
	Plants	– unicellular or multicellular – nucleus/nuclei – cell wall/walls – chloroplasts
	Animals	– unicellular or multicellular – nucleus/nuclei – no cell wall/walls – no chloroplasts

- Bacteria and archaea are called prokaryotes.
 - A prokaryote consists of a single small cell with no nucleus.
 - A eukaryote consists of one or more larger cells (with a nucleus).

OBJECTIVE 2

You must be able to distinguish between a species and a breed and say what role DNA plays in this.

- Organisms belong to a single species if they are able to have fertile offspring together.
- Organisms of a single species can belong to different breeds.
 - The external appearance of the breeds can be very different.
 - Organisms that are members of different breeds within the same species are able to reproduce together. For example: different breeds of dogs.
- The DNA of organisms that belong to the same species shows a lot of similarities.

OBJECTIVE 3

You must be able to list features of bacteria and archaea. You must also be able to describe the roles bacteria play for humans.

- Bacteria and archaea reproduce by division.
- Bacteria can:
 - clear away the remains of dead organisms in nature;
 - be used in the preparation of some foodstuffs (e.g. yoghurt, sauerkraut);
 - cause food to go bad;
 - cause infectious diseases (e.g. cholera, pneumonia, ear infections and tuberculosis) that can be tackled with antibiotics (e.g. penicillin).
- Archaea often live in extreme conditions (e.g. hot, acidic springs or the gut of humans).

OBJECTIVE 4

You must be able to list features of fungi. You must also be able to describe the roles fungi play for humans.

- Yeasts are unicellular fungi.
 - Yeasts reproduce by division.
- Multicellular fungi generally form long, thin filaments (hyphae).
 - Multicellular fungi generally reproduce through spores (cells that can grow into a new fungus).
 - In some types of fungus, the spores are produced in toadstools.
- Most types of fungus feed on the dead residues of organisms.
 - In nature, they clear up the remains of organisms.
 - They can make food go bad.
- Fungi can cause infectious diseases (e.g. athlete's foot).
 - These infectious diseases can be tackled using medicines (antibiotics for some infections).
- Fungi can be used by people:
 - in the production of medicines (e.g. penicillin);
 - in the preparation of foodstuffs (e.g. bread, beer, wine, blue cheese);
 - as foodstuffs: the toadstools of some species of fungi can be eaten (e.g. mushrooms).

OBJECTIVE 5

You must be able to divide the plant kingdom into three phyla. You must be able to list the features of each phylum, with examples.

Phylum	Features	Examples
Algae	– no leaves, no stems and no flowers	– Pleurococcus (unicellular) – bladderwrack (multicellular) – stonewort (multicellular)
Spore-bearing plants	– roots, stem, leaves – no flowers – reproduction through spores	– common hair moss – male fern
Seed-bearing plants	– roots, stem, leaves – flowers – reproduction through seeds	– beech – ivy – dandelion

OBJECTIVE 6

You must be able to divide the animal kingdom into seven phyla. You must be able to list the features of each phylum, with examples.

Phylum	Features	Examples
Sponges	– asymmetric – a skeleton of tough keratin fibres between the cells – generally fixed to the seabed	– red finger sponge – yellow tube sponge
Cnidarians	– radially symmetrical (can be divided in several ways into two approximately equal halves) – generally have no skeleton – live in water – catch their prey with tentacles	– compass jellyfish – sea anemone
Worms	– bilaterally symmetrical (there is only one way that such animals can be 'cut' to create two roughly equal halves) – no skeleton – the body is long and thin	– tapeworm – roundworm – earthworm

Phylum	Features	Examples
Molluscs	– bilaterally symmetrical – generally have a shell as a skeleton	– squid – mussel – snail
Arthropods	– bilaterally symmetrical – external skeleton (cuticle) – jointed legs – the body consists (at least partly) of segments	– centipede – crab – spider – fly
Echinoderms	– radially symmetrical – internal skeleton of calcium carbonate – the skin is covered with spines or nodules – live on the seabed	– sea urchin – sea cucumber – starfish
Vertebrates	– bilaterally symmetrical – an internal skeleton with a backbone	– badger – frog – sand lizard

OBJECTIVE 7

You must be able to list the features of unicellular eukaryotes that are not classified in the plant, animal or fungal kingdoms.

- single-celled eukaryotic organisms have no skeleton.
 - They live mostly in water.
 - Examples: amoeba and paramecium.
- Amoeba.
 - They move by producing pseudopods (the cytoplasm moves in a particular direction via the pseudopod).
 - They feed by creating food vacuoles: pseudopods enclose food (e.g. bacteria). The food is digested in food vacuoles and then absorbed into the cytoplasm.
 - Undigested residues are eliminated through the cell membrane.
- Paramecium.
 - Move using cilia.
 - Feeding: the cilia make the food move via the mouth pore into a food vacuole. The food is digested in food vacuoles and then absorbed into the cytoplasm.
 - Undigested residues are eliminated through the anal pore.

OBJECTIVE 8

You must be able to name the groups that are defined by further dividing a phylum and you must be able to classify organisms using a branching tree.

- A phylum is divided further into classes, orders, families, genera and species.
 - For example: the vertebrate phylum is subdivided into the classes of mammals, birds, and so on. The class of mammals can then be divided further into the orders of carnivores, rodents, and so forth.
- The more two organisms (and their DNA) are alike, the more closely related they are to each other and the more they will be classified into the same groups.
 - Organisms and their DNA are most alike and most closely related when they belong to the same species.
 - Organisms and their DNA are least alike and least closely related when they come from different domains.

OBJECTIVE 9

You must be able to subdivide the arthropod phylum into four main groups. You must be able to list the features of each main group, with examples.

Order	Features	Examples
Myriapods	– the entire body is made up of segments – there are legs on each segment	– millipede – giant centipede
Crustaceans	– ten or more legs	– shrimp – crayfish
Arachnids	– eight legs	– harvestman – garden spider
Insects	– six legs – head, thorax and abdomen – legs and (often) wings are on the thorax	– beetle – ant – butterfly

OBJECTIVE 10

You must be able to subdivide the vertebrate phylum into five classes. You must be able to list the features of each class, with examples, and explain the relationships between the features.

Class	Features	Examples
Fishes	– skin covered in scales and slime – cold-blooded – breathe using gills – reproduction: eggs without shells – environment: in the water	– trout – herring – cod – plaice – pike
Amphibians	– skin covered with slime – cold-blooded – breathe using gills and skin at first, later with lungs and through skin – reproduction: eggs without shells – environment: in water and on land	– frog – toad – newt
Reptiles	– skin covered with dry scales – cold-blooded – breathe using lungs – reproduction: eggs with leathery shells – environment: on land	– lizard – crocodile – grass snake – tortoise
Birds	– skin covered with feathers – warm-blooded – breathe using lungs – reproduction: eggs with calcium carbonate shell – environment: in the air	– buzzard – grebe – blackbird – owl – swallow
Mammals	– skin covered with hairs – warm-blooded – breathe using lungs – reproduction: viviparous, young drink milk (suckle) from the mother – environment: on land	– dog – elephant – whale – wolf – seal

OBJECTIVE 11

You must be able to use an identification table for organisms.

EXTRA OBJECTIVE 12

You must be able to subdivide the phylum of seed-bearing plants into two groups. You must be able to list the features of each group, with examples.

Family	Features	Examples
Conifers	– seeds between the scales of cones – leaves are generally needles	– fir – spruce
Flowering plants	– seeds in fruit – leaves not needles	– cherry tree – dandelion

SKILLS AND COMPETENCIES

BASICS

- You have learned how to read and make a pie chart.
- You have learned how to make a written project.
- You have practised doing a practical activity.
- You have practised making drawings.
- You have practised working with a magnifying glass and a microscope.
- You have practised using the Internet and reference material.

EXTRA

- You have practised using the Internet and reference material.
- You have carried out an assessed practical and made drawings.

The diagnostic test does not include any questions about these competencies/skills.

You have met a molecular biologist and a medical microbiology technician in this unit.
You have also seen applications in science and daily practice that use the material from this unit.

Diagnostic test

You can use this test to check for yourself whether you understand and can apply the objectives listed in the summary. Write down the answers on the score sheet in your workbook.

OBJECTIVE 1

Answer the following questions.

In figure 78 you can see four different organisms or parts of organisms.

- 1 Which of these organisms will have cells that do not have nuclei?
- 2 Which of these organisms will have cells that do not have walls?
- 3 Which of these organisms have cells that could have chloroplasts?
- 4 Which organism is a prokaryote?

▼ Fig. 78

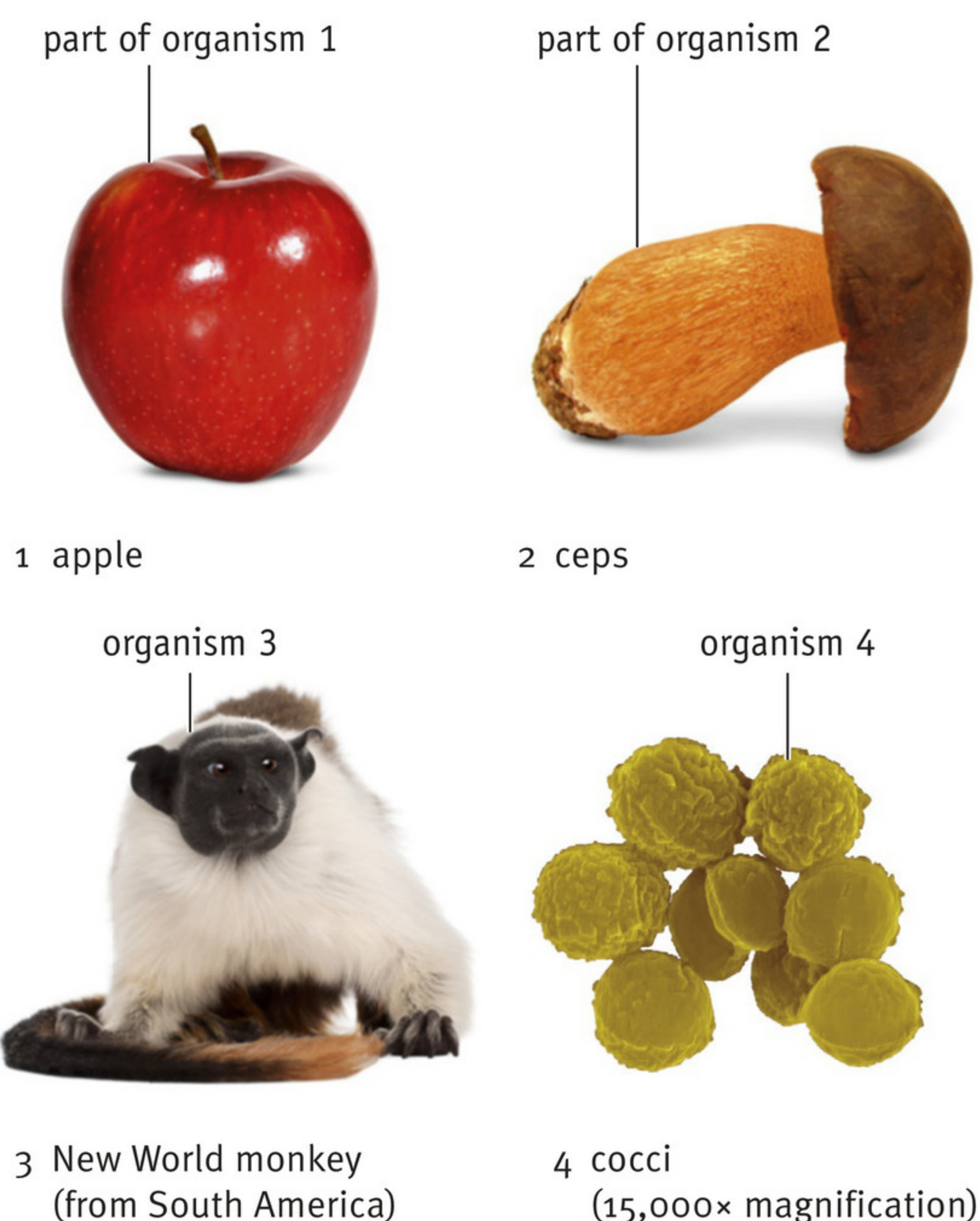
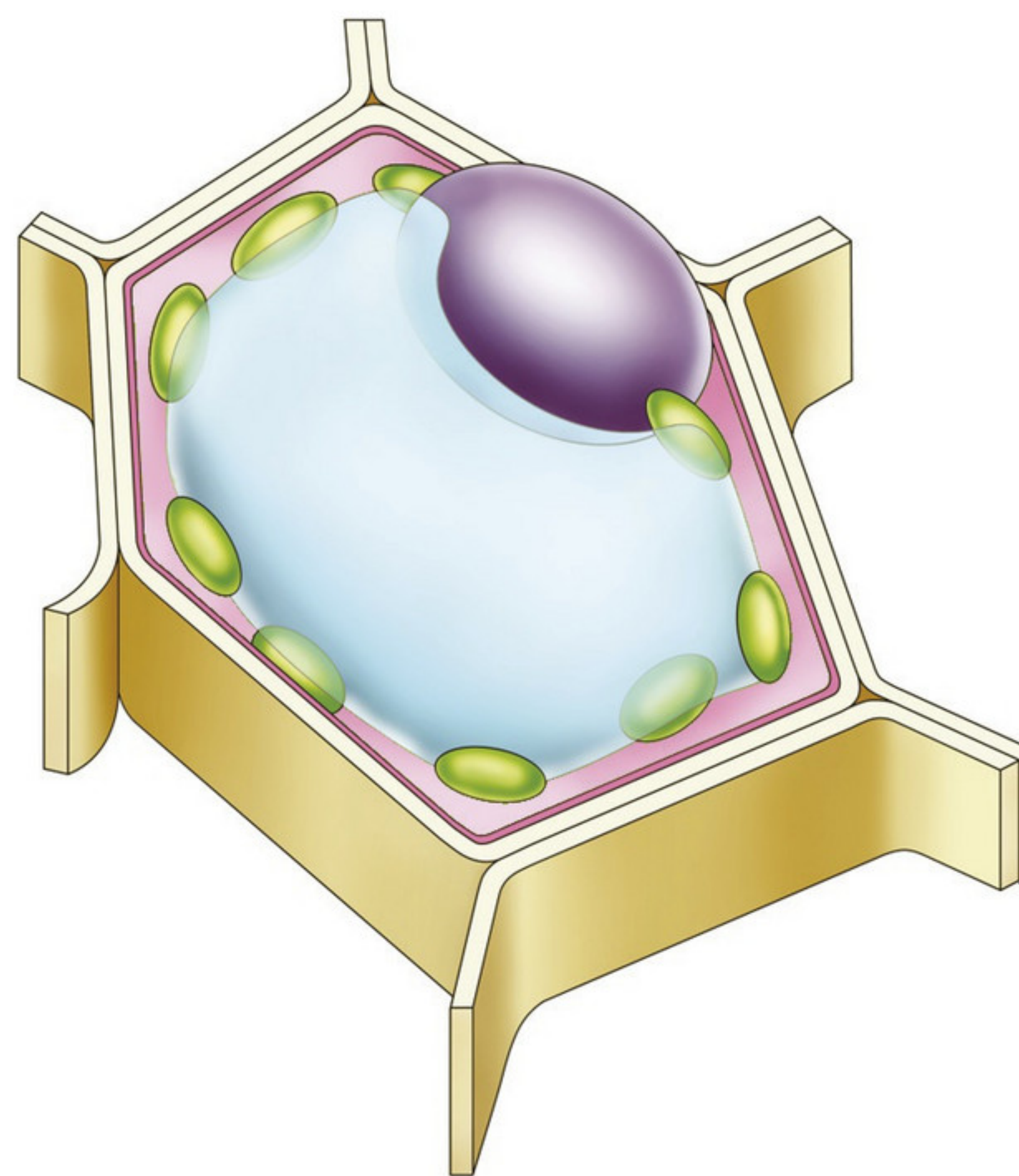


Figure 79 is a schematic drawing of a cell.

- 5 Which domain does the organism belong to that this cell comes from?
- 6 Which kingdom does the organism belong to that this cell comes from?

▼ Fig. 79



OBJECTIVE 2

Say whether each of the following statements is true or false.

- 1 Organisms belong to a single species because they look very alike.
- 2 Organisms belong to a single species if they are able to have fertile offspring together.

Figure 80 shows two breeds of cat. Statements 3 to 5 are about this figure.

- 3 The sphynx and the British shorthair belong to a single species.
- 4 A sphynx and a British shorthair can have fertile offspring together.
- 5 The DNA of a sphynx and a British shorthair is very similar.

▼ Fig. 80 Breeds of cat.



1 sphynx

2 British shorthair

OBJECTIVE 3

Answer the following questions.

- 1 How do archaea generally reproduce?
- 2 Name a useful function that bacteria have in nature.
- 3 You can treat impetigo with an ointment (see figure 81).
What kind of medicine will this ointment probably contain?
- 4 List one useful role bacteria play in food for humans and one harmful role.

▼ Fig. 81

Impetigo

Impetigo is a very contagious skin infection that is caused by staphylococci (a type of bacterium). There are usually small wounds, vesicles and red spots around the mouth or nose that later produce crusts. The infection can however appear anywhere on the body. Impetigo is treated by smearing an ointment on the wounds.

OBJECTIVE 4

Say whether each of the following statements is true or false.

- 1 Yeasts are made up of hyphae.
- 2 Multicellular fungi mostly reproduce by division (binary fission).
- 3 Toadstools are involved in the reproduction of fungi.
- 4 Figure 82 shows you that fungi are useful.

▼ Fig. 82



- 5 The condition described in figure 83 is caused by a fungal infection.

▼ Fig. 83

Tinea pedis

A condition in which the skin between the toes is inflamed. The condition generally starts between the fourth and fifth toes with itching, redness, skin flaking and sometimes cracked skin. If there is an allergic response, in some cases vesicles can suddenly appear on the palms of the hands and fingers.

- 6 Yeasts are used in the production of the antibiotic penicillin.
- 7 Mushrooms (see figure 84) are edible fungi.

▼ Fig. 84 Mushrooms.



- 8 Multicellular fungi are used in beer-making.

OBJECTIVE 5

Place crosses in the correct columns.

The plant kingdom is subdivided into phyla.

- 1 Which phylum contains single-celled plants?
- 2 The green deposit on the door in figure 85 is made of organisms that belong to the plant kingdom. Which phylum of the plant kingdom do these organisms belong to?

▼ Fig. 85



3 Which phylum does the plant shown in figure 86 belong to?

▼ Fig. 86



4 Which phylum does the plant shown in figure 87 belong to?

▼ Fig. 87 Greater fork moss.



5 Which phylum does the water plant shown in figure 88 belong to?

▼ Fig. 88 Indian lotus.



6 Which phylum do plants belong to if they have part P shown in figure 89?

▼ Fig. 89



OBJECTIVE 6

Answer the following multiple choice questions.

- 1 A guide to animals has the following description next to a photo: “The animals are asymmetric. They have a skeleton of tough keratinous fibres between the cells and they live fixed in place on the seabed.” What kind of animals would you see in the photo in the animal guide?
- A Cnidarians.
 - B Sponges.
 - C Echinoderms.
 - D Molluscs.

There are four photos of animals in figure 90. Questions 2 to 5 are about these animals.

- 2 Which of the animals shown are bilaterally symmetrical?
- A Only animals 1 and 2.
 - B Only animals 2 and 3.
 - C Only animals 2 and 4.
 - D Only animals 3 and 4.

- 3 Which of the animals shown has a skin that is covered in spines or nodules?
- A Animal 1.
 - B Animal 2.
 - C Animal 3.
 - D Animal 4.
- 4 Which of the animals shown have a skeleton?
- A Only animals 2 and 3.
 - B Only animals 2 and 4.
 - C Only animals 2, 3 and 4.
 - D Animals 1, 2, 3 and 4.
- 5 Which of these animals are radially symmetrical?
- A Animals 1 and 2.
 - B Animals 1 and 4.
 - C Animals 2 and 3.
 - D Animals 3 and 4.

▼ Fig. 90



1 jellyfish



2 clown triggerfish



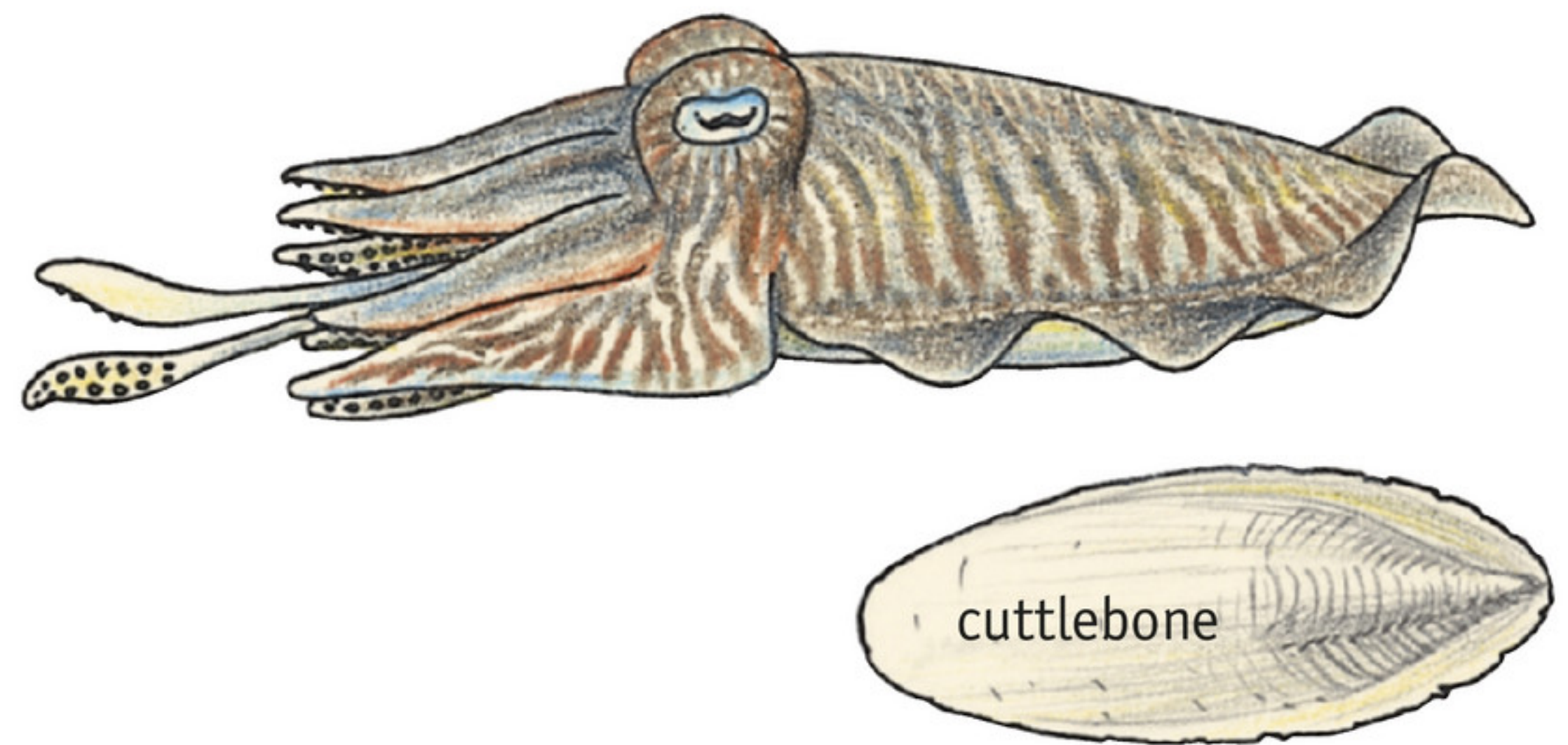
3 praying mantis



4 starfish

- 6 Figure 91 is a drawing of a cuttlefish. Which phylum of the animal kingdom does a cuttlefish belong to?
- A The arthropods.
 - B The vertebrates.
 - C The cnidarians.
 - D The molluscs.

▼ Fig. 91 Cuttlefish.



- 7 Figure 92 is a photo of a chameleon. Which phylum of the animal kingdom does a chameleon belong to?
- A The arthropods.
 - B The vertebrates.
 - C The echinoderms.
 - D The molluscs.

▼ Fig. 92 Chameleon.



OBJECTIVE 7

Answer the following questions.

The amoeba and the paramecium are two unicellular eukaryotes.

- 1 Which organism is shown in figure 93: an amoeba or a paramecium?

▼ Fig. 93



- 2 Does an amoeba have food vacuoles? And does a paramecium have them?
- 3 Which organism eliminates undigested food remains through the anal pore?

- 4 Which organism can keep changing shape?
- 5 Which organism eliminates undigested food remains through the cell membrane?

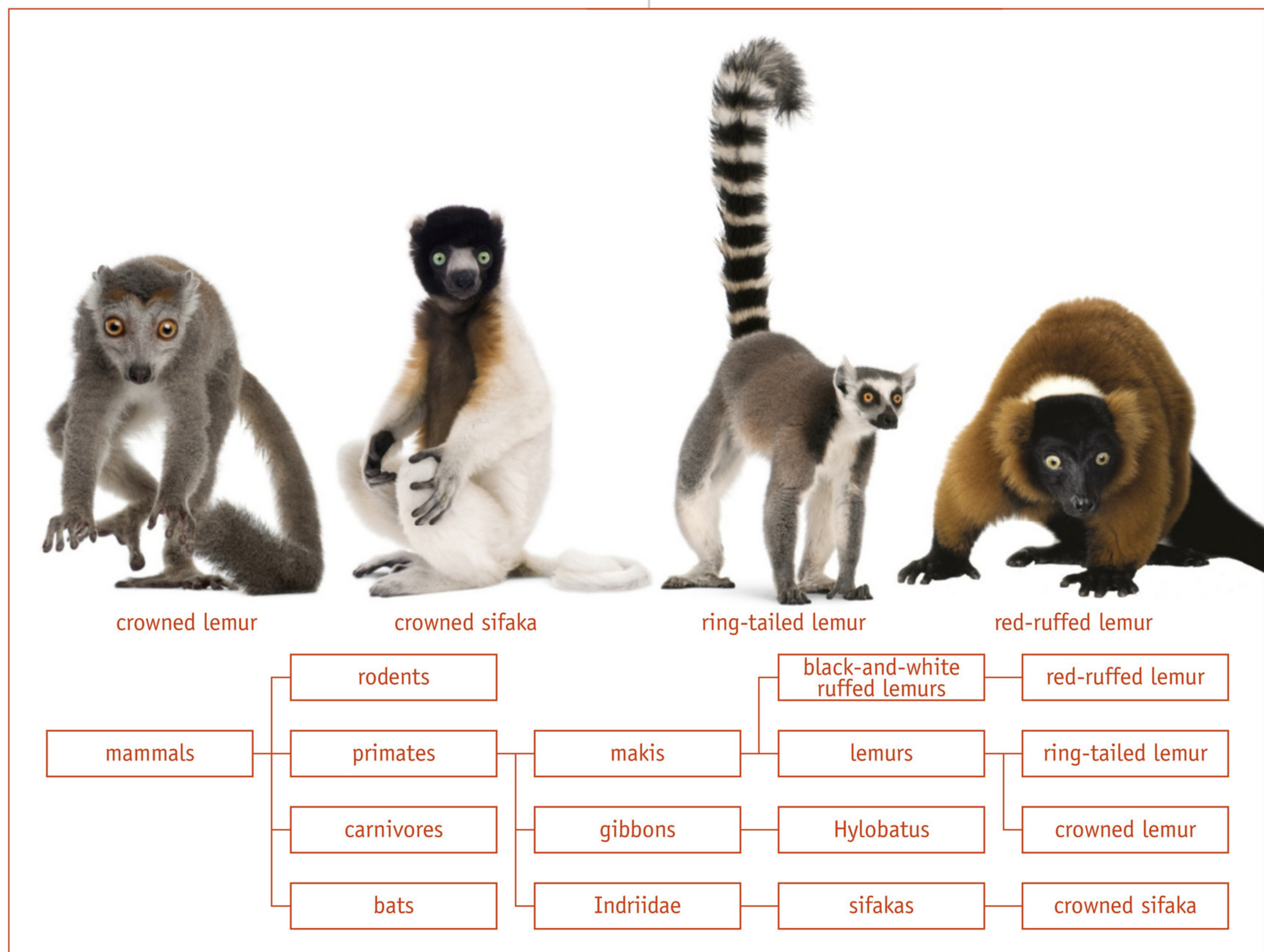
OBJECTIVE 8

Answer the following multiple choice questions.
Figure 94 shows you four mammals and the classification of various mammals.

- 1 Mammals are one of the subdivisions of the vertebrates.
What kind of group are the mammals?
 - A A family.
 - B A genus.
 - C A class.
 - D An order.
- 2 What is the group of lemurs known as?
 - A A family.
 - B A genus.
 - C A class.
 - D An order.

- 3 Three of the animals are the crowned lemur, the crowned sifaka and the red-ruffed lemur.
How are these animals related to the ring-tailed lemur (from most to least closely related)?
 - A crowned sifaka – crowned lemur – red-ruffed lemur
 - B crowned sifaka – red-ruffed lemur – crowned lemur
 - C crowned lemur – crowned sifaka – red-ruffed lemur
 - D crowned lemur – red-ruffed lemur – crowned sifaka
- 4 There are similarities between the red-ruffed lemur and the ring-tailed lemur. Even so, further subdivision of the mammals does place them in different groups. Which statement about these groups is correct?
 - A Red-ruffed lemurs and ring-tailed lemurs belong to different families.
 - B Red-ruffed lemurs and ring-tailed lemurs belong to different genera.
 - C Red-ruffed lemurs and ring-tailed lemurs belong to different classes.
 - D Red-ruffed lemurs and ring-tailed lemurs belong to different orders.

▼ Fig. 94



OBJECTIVE 9

Answer the following questions.

Arthropods can be divided up into four groups: insects, crustaceans, arachnids and myriapods.

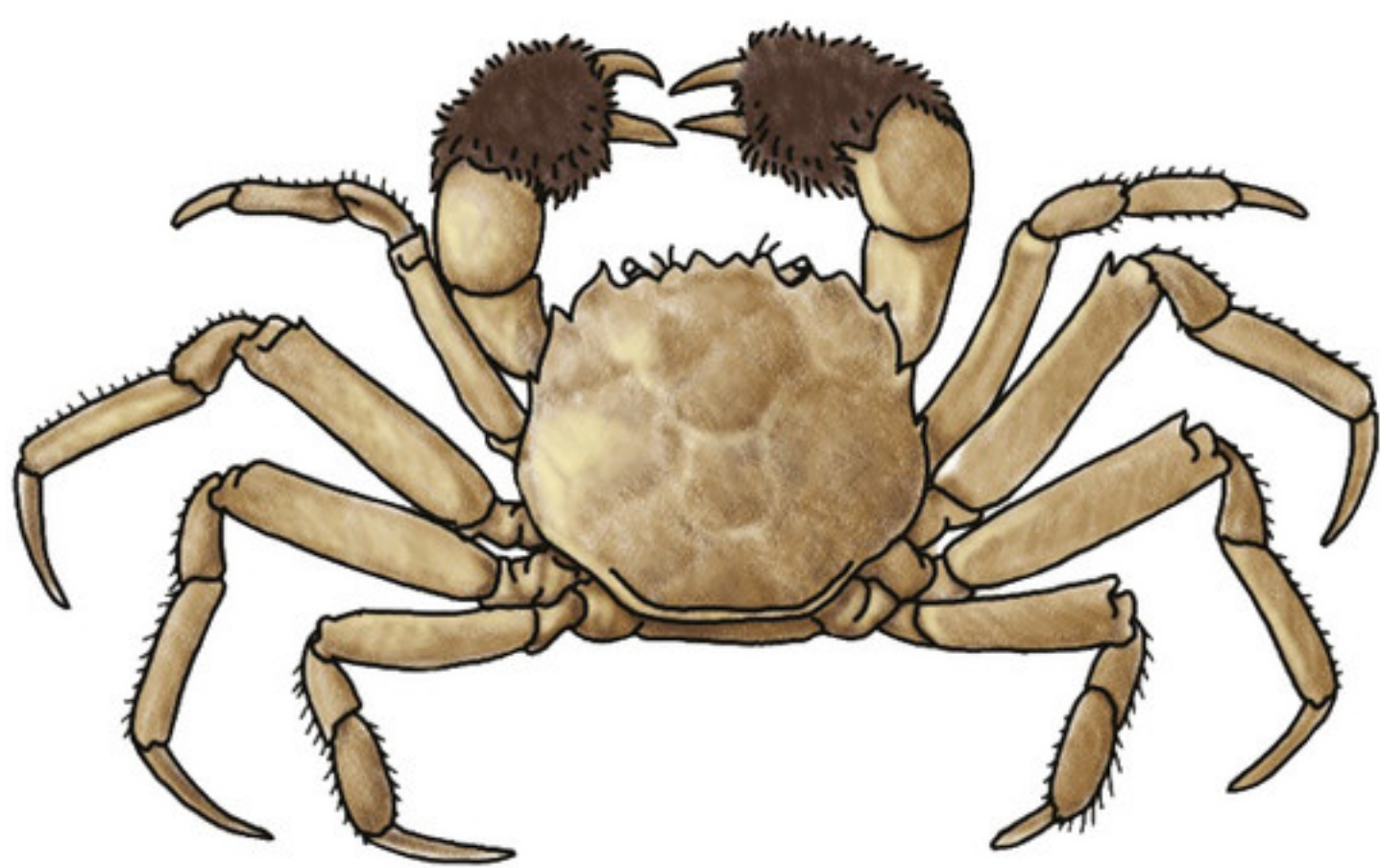
- Figure 95 shows you a predator with its prey. Which group of arthropods does this predator belong to? And which group of arthropods does the prey belong to?

▼ **Fig. 95** Eight-legged predator catches prey.



- Which group of arthropods does the animal shown in figure 96 belong to?

▼ **Fig. 96**



- List two features of myriapods that you can see in the millipede shown in figure 97.

▼ **Fig. 97** Millipede.



- List three features of insects that you can see in the ant shown in figure 98.

▼ **Fig. 98** Ant.

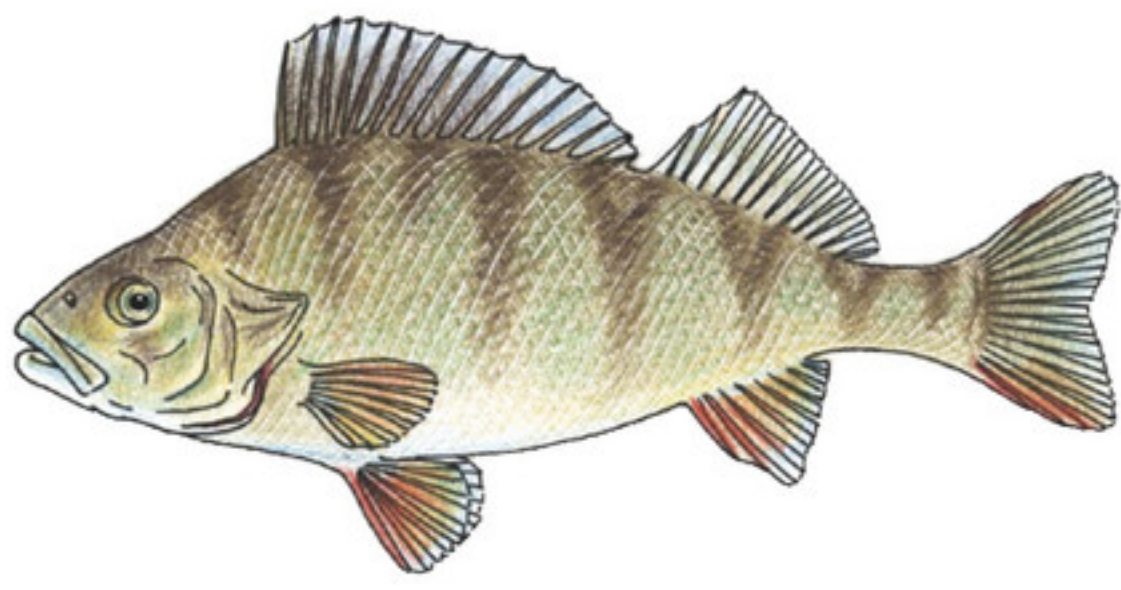
**OBJECTIVE 10**

Answer the following questions.

The questions are about the vertebrate phylum.

- In which class of vertebrates do the animals change the way they breathe during the course of their lives?
- Figure 99 shows four species of vertebrates. In which of these four species does the female lay eggs to reproduce?
- Is a starling warm-blooded or cold-blooded?
- The skin of a bat (see figure 100) is covered with hairs. Does a bat produce live young or does it reproduce by laying eggs?

▼ Fig. 99



1 perch



2 tree frog



3 starling



4 sloth

▼ Fig. 100 Bat.



▼ Fig. 102

Dugong

The dugong is a marine animal that mostly eats water plants. To eat, a dugong dives to the bottom of shallow seawater to look for food. After a few minutes, the animal comes to the surface again to breathe. The young are born at shallow spots along the coast. A baby dugong drinks milk from the mother animal. After about eighteen months, the young animal moves onto solid food. The young stay with their mothers until a new baby is born.



5 How does the animal shown in figure 101 breathe?

▼ Fig. 101



- 6 Some vertebrates lay eggs with a calcium carbonate shell.
Where do these animals lay their eggs: on land or in the water?
- 7 In the winter, the water in a lake is about 4°C .
Will the body temperature of the fish in this lake be much higher than the water temperature, or much lower, or will there not be much difference? Explain your answer.
- 8 Read the article in figure 102.
What class of animals does the dugong belong to?
State which two sentences in the text tell you that.

OBJECTIVE 11

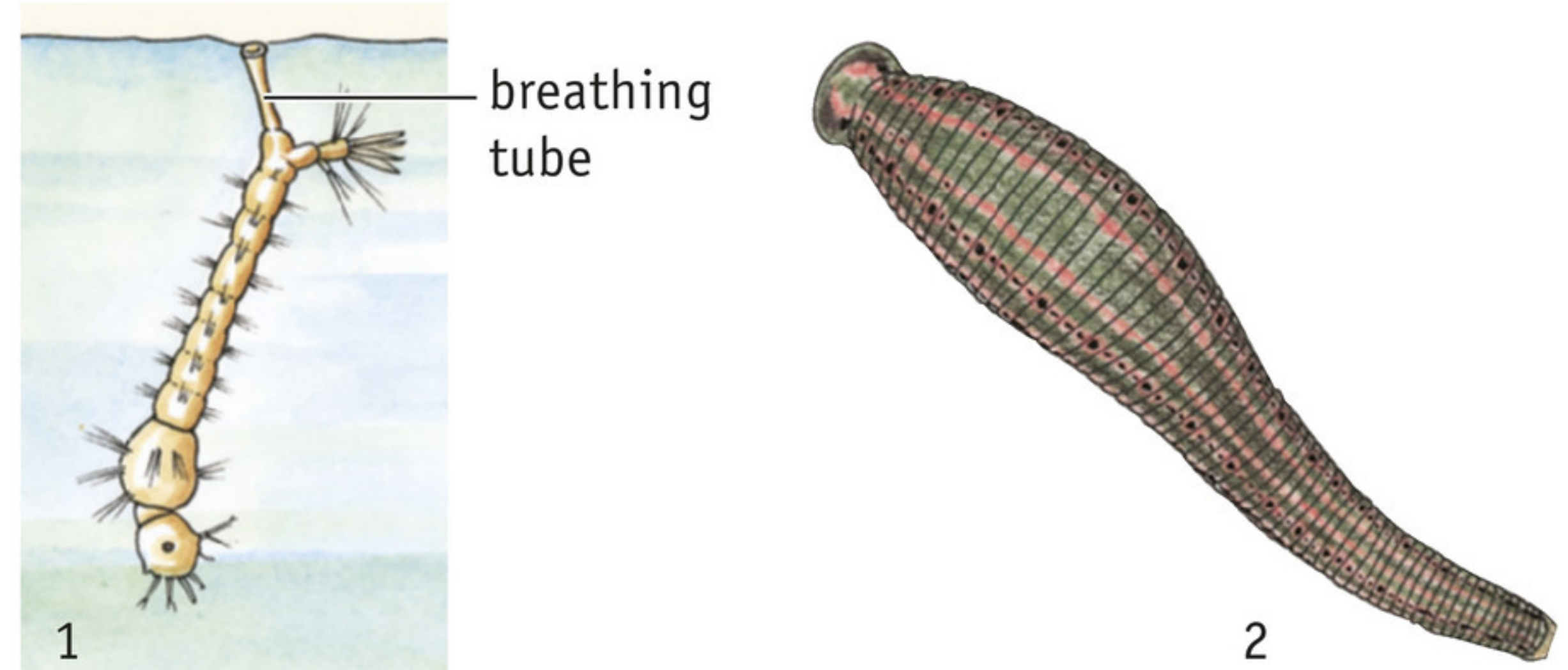
Figure 103 is an identification table for several small water animals.

Two small water animals are shown in figure 104.

- Use the identification table in figure 103 to identify these animals.
- Make a note of the name of the animal species and write down the steps you took through the identification table.

▼ **Fig. 103****Identification table for several small water animals**

- | | | |
|------|--|--------------------------|
| 1 a | The animal is a couple of millimetres in size..... | 2 |
| b | The animal is bigger than a couple of millimetres. | 3 |
| 2 a | The animal has a tail | copepod |
| b | The animal has no tail | water flea |
| 3 a | The animal looks like a small ball | water mite |
| b | The animal does not look like a small ball | 4 |
| 4 a | The animal has real legs that are more than 5 mm long | 5 |
| b | The animal does not have real legs | 8 |
| 5 a | The animal has a house of twigs, leaves or sand grains | caddis fly |
| b | The animal does not have a house of twigs, leaves or sand grains | 6 |
| 6 a | The animal has four legs..... | newt |
| b | The animal does not have four legs..... | 7 |
| 7 a | The animal has six legs | dragonfly larva |
| b | The animal has eight legs | water spider |
| 8 a | The animal has a tail that is longer than the rest of the body | hoverfly larva |
| b | The animal has a tail that is shorter than the rest of the body or it has no tail..... | 9 |
| 9 a | The animal has a scaly skin and fins..... | goby |
| b | The animal does not have a scaly skin and fins..... | 10 |
| 10 a | The animal has a shell..... | 11 |
| b | The animal does not have a shell | 13 |
| 11 a | The shell has a spiral pattern | 12 |
| b | The shell does not have a spiral pattern..... | freshwater mussel |
| 12 a | The shell is flat..... | ramshorn snail |
| b | The shell is not flat..... | pond snail |
| 13 a | The animal has a thick, rounded body..... | tadpole |
| b | The animal has a long body | 14 |
| 14 a | The animal is smooth | leech |
| b | The animal has hairs on the body ... | mosquito larva |

▼ **Fig. 104** The animals are shown at approximately 2× actual size.**EXTRA OBJECTIVE 12**

Answer the following questions.

We subdivide seed-bearing plants into two groups: conifers and flowering plants.

Figure 105 shows you some plants and parts of plants.

- 1 Which group of seed-bearing plants does a plum tree belong to?
- 2 Which group of seed-bearing plants does a bonsai tree belong to?
- 3 Which group of seed-bearing plants do spruce cones come from?
- 4 Which group of seed-bearing plants do carrots belong to?

▼ **Fig. 105**

You can do the extension if you have time left over. You can choose between different topics. This unit's extension consists of three topics. You can do the exercises for them in your workbook. Your teacher will tell you how many topics you should choose.

1 Edible animals

You have learned that biologists divide the animal kingdom into phyla, classes, orders, families, genera and species. In this extension, you are going to classify a number of animals that are eaten. Some animals are eaten a lot, such as cattle and pigs. Molluscs and arthropods are not eaten so often in the Netherlands, but you can still usually buy some from the supermarket. Molluscs can be subdivided into eight classes. Three well-known classes of molluscs are **squids**, **bivalves** and **snails**. In bivalves, the shell consists of two half shells that can open and close. Insects are not eaten often in the Netherlands, although increasing numbers of people do like them. There are already certain restaurants where you can eat insects.

WB EXERCISES 1 AND 2, PAGE 145

▼ **Fig. 106** A number of products that are eaten in the Netherlands.



1 crab salad



2 meatballs



3 escargots



4 mussels



5 veal croquette



6 prawns



7 deep-fried grasshoppers



8 chicken leg



9 calamari (deep-fried squid rings)

2 Live fish food

You can often buy various sorts of live fish food in pet shops. These are usually worms, larvae or small crustaceans (see figure 107) that are sold in bags of water. Crustaceans that are used as food include water fleas, amphipods and copepods. Figure 108 shows you brine shrimps (artemia) that are used in saltwater aquariums. Worms that are used as fish food are tubifex and enchytraeids. Tubifex is a red sludge worm. Enchytraeids are small white worms. Insect larvae are also sold as live fish food (see figure 109), such as red and white mosquito larvae.

In this extension you are going to look at the structure of an animal that is used as live fish food. You will make drawings of it.

WB EXERCISE 1, PAGE 147

▼ **Fig. 107** Live fish food.



1 worms (tubifex)



2 larva (mosquito larva)



3 copepod

▼ **Fig. 108** Brine shrimps (artemia).



▼ **Fig. 109** Live fish food.



A	
abdomen	141
abscission layer	59
adductor muscles	152
adductor muscles, attachment scar of	153
adolescence	21
adolescents	21
adult	21
adult, young	21
algae	126
algae, multicellular	126
algae, unicellular	126
altricial	27
amoeba	135
amphibians	142
amyloplasts	88
anal pore	136
angiosperm plants	151
animals	115
annual ring	48
antibiotics	122
arachnids	140
archaea	115, 120
arm	82
arthropods	132
asymmetrical	130
athlete's foot	124
attachment scars of adductor muscles	153
axil	47
axillary bud	47
B	
baby	21
backbone	142
bacteria	115, 120
bacterial infections	122
bean (brown, broad, kidney)	12
beard (mussel)	153
bilaterally symmetrical	130
biosphere	93
birds	142
bivalves	167
bladderwrack	126
blade (leaf)	51
body cells	91
body segments	141
body temperature	142
branching tree	139
breathing	9
breeds	117, 137
bud (yeast)	123
bud scale	59
buds, dormant	59
C	
Cabbage White butterfly	20
carbon dioxide	53
caring	24
caterpillars	20
cell, daughter	96
cell, parent	96
cell, stem	97
cell membrane	87, 136
cell nucleus	87, 115
cell organelles	88
cell wall	88, 115
cells	81, 93
characteristic	9, 114
characteristics, inherited	92
chloroplasts	88, 115, 116
chromoplasts	88
chromosomes	91
cilia	136
classes	137
closely related	139
cnidarians	132
cocoon	20
cold-blooded animals	142
collecting	12
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